Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

The Eleventh Report in a Series on
Efficiency in Fruit Marketing

COSTS AND EFFICIENCY IN PACKER SUPPLY OPERATIONS FOR FRESH TABLE GRAPES

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FOREWORD

This is the eleventh in a series of reports on costs and efficiency in the marketing of deciduous fruits. Previous reports have dealt with particular phases of packing house operation and with economies of scale in pear packing. The present report is concerned with a group of activities in grape packing house operation that, for convenience, are defined as the "packer supply operations." These include receiving and transporting incoming fruit and empty field boxes, supplying fruit to the packers, and disposing of culls.

Studies of the costs of a number of grape packing firms indicate wide variation in the costs of the packer supply operations per packed lug. Part of the observed cost differences are due to differences in operating conditions. For example, capacity rates of plant output in the plants studied varied from about 140 to 1,150 packed standard lugs per hour; average rates of packer output ranged from about 4 to 31 lugs per packer hour; proportion of cull fruit varied from roughly 9 to 46 per cent of the total fruit run; and length of season ranged from approximately 3 to 16 weeks per year. The type of equipment and work methods used and the level of efficiency achieved in individual plants also appeared to be important factors.

The purpose of this report is to indicate how costs are affected by variations of the type described and to suggest possibilities of cost reduction in individual plants through adoption of more efficient methods.

These studies were made cooperatively by the Giannini Foundation of Agricultural Economics of the Agricultural Experiment Station, University of California, Berkeley, and the Agricultural Marketing Service, U. S. Department of Agriculture. They were made under authority of Title II of the Research and Marketing Act of 1946.

COSTS AND EFFICIENCY IN PACKER SUPPLY OPERATIONS FOR FRESH TABLE GRAPES

L. L. Sammet[1]

INTRODUCTION

In centralized houses for packing California fresh table grapes, the principal operations include receiving incoming fruit and supplying it to the packers, returning empty field boxes to the grower's truck, disposing of cull fruit, receiving and assembling container materials and supplying containers to the packer, lidding and transporting packed fruit, and loading packed fruit for shipment. How these operations are related to each other, and a few possibilities of alternate procedures in particular operations, are illustrated in the process chart, Figure 1.

Operations Studied

Only a part of the over-all plant operation is considered in this report. The operations studied are shown in the unshaded portion of Figure 1 and include receiving and transporting incoming fruit, setting up fruit to the packers, returning empty field boxes to the grower's truck, and disposal of cull fruit. For convenience, this group of activities is referred to as the packer supply operations. Operations not included in the present analysis are shown in the shaded portion of the process chart.

The key packing house operation--culling and packing the fruit--is shown partly in both areas of the process chart. This reflects the classification of costs found necessary in the analysis, which associates the costs of the packing-line equipment with the packer supply operations, while excluding from this category the labor costs of culling and packing. The basis for this classification is evident in later sections of this report.

COSTS OF THE PACKER SUPPLY OPERATIONS IN SAMPLE PLANTS

Costs of the packer supply operations per packed standard display lug as shown by analysis of the accounting records of 21 different firms are

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[1] L. L. Sammet is Specialist in the Experiment Station, University of California and Cooperative Agent of the Agricultural Marketing Service, U. S. Department of Agriculture.

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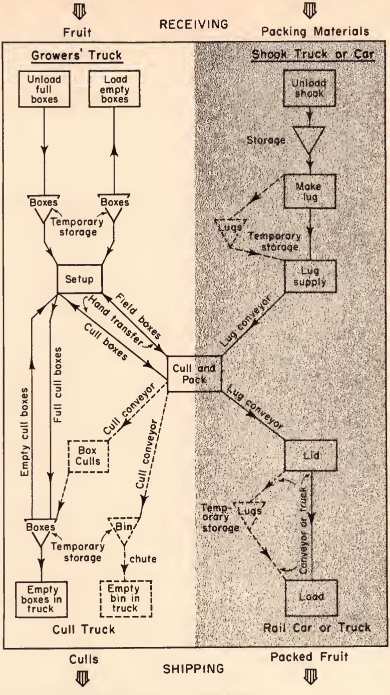

Note: Alternate methods shown by broken lines.
Arrows indicate transport of product or materials. Unless otherwise indicated, transport is by hand truck or fork-lift truck.

Fig. 1. Process chart for packing fresh table grapes. The operations illustrated in the unshaded area pertain to receiving fruit, supplying it to the packers, and disposing of culls, the costs of which are analyzed in this report. Operations in the shaded area are considered in separate studies. The culling and packing operation is borderline. The costs of building space and packing-line equipment are included in the present study, but the labor costs of culling and packing are not.

summarized in Table 1. Computation of these costs was based on a standardized procedure designed to focus on internal plant efficiency. This involved calculation of costs in each plant on the basis of its full, or nearly full, output rate, use of a uniform wage schedule for all plants, and a uniform procedure of estimating annual fixed costs for equipment, except for variations necessary to reflect differences between plants in the types of equipment used.1/

Costs of the packer supply operations are shown by Table 1 to be a substantial part of the total packing costs, averaging about 18 per cent of the total labor and equipment costs. The table also indicates a significant difference in the unit costs of the packer supply operations of different plants. The estimated costs of these operations ranged from 2.7 cents per packed lug in Emperor grape plant No. 22 to 13.8 cents per lug in summer grape plant No. 7, a difference of 11.1 cents per packed lug. In relative terms, the estimated costs of the packer supply operations were more than 5 times greater in the high-cost than in the low-cost plant. An even greater relative difference is found if only the costs of labor are compared.

Since a uniform procedure was used in computing costs for each plant in Table 1, the considerable range in unit costs suggests that differences in work method and type of equipment and variation in other factors reflected in the table have an important effect on the unit costs of the packer supply operations in different plants.

Factors Affecting Costs

Of numerous factors affecting the costs of the packer supply operations, the most significant are type of equipment used, the proportion of cull fruit, the rate of output per packer hour, and the size of plant. One might hope for an indication in Table 1 of how variations in these factors affect costs, but the many different combinations with respect to these factors found in the sample plants make their effects difficult to isolate. The table does, however, help to identify these factors. Variations of the following nature are reflected in the table:

1/ The "full output rate" was defined in each plant as the average hourly output rate for the three days of highest average rate in a sample of days in the season. For a more complete discussion, see Sammet, L. L., and B. C. French, "Costs of Packing Fresh Grapes," California Agriculture, vol. 9, no. 2, March, 1955, pp. 2, 14.

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TABLE 1

Costs of Packer Supply Operations in a Sample of Plants
Packing Fresh Table Grapes, California, 1953[a]
(Costs Computed by Applying Uniform Estimating Procedures to Accounting Record Data)

Variety of grape	Plant number	Type of equipment[b]			Output data[c]			Costs of packer supply operations[a]			
		Trucking	Packing	Culls	Culls, per cent of total run	Lugs per plant hour[d]	Lugs per packer hour[d]	Labor[e]	Equipment[f]	Total	Per cent of total labor and equipment costs
								cents per packed lug			
Emperor	6	HT	M	NM	38.9	849	5.2	5.5	2.2	7.7	16.1
	8	FT	C	M	31.6	384	10.7	2.3	4.4	6.7	20.5
	9	HT	C	M	21.8	616	30.8	1.7	2.1	3.8	15.1
	10	FT	C	M	22.9	639	19.4	0.8	3.2	4.0	17.2
	11	HT	M	NM	14.3	848	22.9	1.9	1.0	2.9	12.8
	13	HT	M	PM	28.0	739	23.8	1.8	1.4	3.2	15.0
	14	HT	M	NM	16.5	810	20.2	2.0	1.0	3.0	8.2
	18	HT	C	M	28.6	614	7.3	2.8	5.6	8.4	40.2
	22	HT	M	NM	10.7	804	29.8	1.7	1.0	2.7	12.4
	23	HT	M	NM	17.9	626	20.9	3.1	1.0	4.1	18.3
	25	HT	C	M	21.9	1,097	20.0	1.7	2.2	3.9	11.9
	28	FT	M	PM	24.3	941	21.4	3.6	2.4	6.0	21.9
Average					23.1	747	19.4	2.4	2.3	4.7	17.5
Tokay	15	HT	C	NM	18.0	267	11.6	1.9	3.6	5.5	19.4
	17	HT	M	NM	18.8	558	14.0	2.4	1.3	3.7	14.9
	20	HT	M	NM	26.0	140	9.3	2.7	3.1	5.8	17.7
	24	HT	M	NM	10.7	201	14.4	3.9	2.0	5.9	20.5
	26	HT	C	PM	19.4	302	19.5	1.1	3.3	4.4	15.4
Average					18.6	294	13.8	2.4	2.7	5.1	17.6
Summer	2	HT	M	NM	16.8	487	7.4	3.6	2.2	5.8	16.7
	3	HT	M	NM	17.0	870	9.4	3.4	1.7	5.1	17.8
	6	HT	M	NM	46.3	1,144	4.2	6.0	3.1	9.1	17.5
	7	HT	C	M	32.4	639	4.1	2.4	11.4	13.8	22.3
	8	FT	C	M	41.4	314	6.5	2.5	6.3	8.8	21.5
	14	HT	M	NM	18.7	650	13.0	2.5	1.6	4.1	17.0
	16	HT	M	NM	8.9	952	13.0	3.4	1.3	4.7	16.8
	18	HT	C	M	34.6	522	5.9	4.3	7.8	12.1	25.3
	25	HT	C	M	25.1	633	12.7	3.0	2.9	5.9	21.3
	28	FT	M	PM	22.9	569	7.5	2.7	4.0	6.7	21.3
Average					26.4	678	8.4	3.4	4.2	7.6	19.8
Grand average					23.5	638	14.3	2.8	3.1	5.8	18.3

[a] Physical rates, such as rates of packing and labor utilization on various jobs, are based on accounting record data for the 1951 packing season. Costs of equipment and labor are based on the 1953 price level.

Costs of packer supply operations include costs of receiving and handling incoming fruit and disposal of culls, packing-line equipment, and building space for these operations.

[b] Equipment code: trucking equipment--HT for hand truck and FT for fork-lift truck; packing equipment--M for manual supply and C for conveyor supply; cull-handling equipment--NM for nonmechanized (culls boxed at packing station), PM for partially mechanized (cull belt to a central cull-boxing station), and M for fully mechanized (cull belt and overhead cull bin).

[c] Average rates for three days of highest output rate of packed fruit.

[d] Standard display lug or weight equivalent, 28 pounds net weight.

[e] Costs of labor based on 1953 wage level in San Joaquin Valley packing districts; in Tokay grape packing districts, wage level averaged about 20 per cent higher.

[f] Unit equipment costs are based on an annual volume that would be packed in 250 hours of operation per season at the plant rate per hour indicated for the individual plant. Annual equipment costs were based on the estimated 1953 replacement costs for equipment and building space required in the individual plant. See Appendix Table F for percentage annual charge applied to different equipment items.

Type of Equipment. The principal variations between plants in type of equipment used occur in the transportation of incoming fruit and culls and in the method of delivering field boxes of fruit to the packers. Transporting full and empty field boxes is done with fork-truck equipment in some plants and with hand-truck equipment in others (see Figure 1 and Table 1). In some plants a conveyor is used for supplying full field boxes to the packers and removing empty field boxes and cull fruit, while in other plants these operations are performed manually (see Figure 2 and Tables 1 and 2).[1] In plants using the manual supply packing-line equipment, the cull fruit commonly is collected in boxes at the individual packing stations, then moved by hand truck or fork truck to a temporary storage area and later to a loading point where the cull boxes are emptied by hand into a highway truck. In some plants using the conveyor supply packing-line equipment, and with some of the manual-type lines, culls are delivered by conveyor belt to a central point where they are collected in boxes, then handled in the manner described above. In still other plants the culls are carried by a conveyor-elevator system from the individual packing stations to an overhead cull bin from which they are periodically emptied by gravity chute to a highway truck.

Proportion of Cull Fruit. As the proportion of culls increases, the number of field boxes and the quantity of cull fruit that must be handled with a given output of packed fruit rises and so does the amount of equipment and labor required for these operations. The importance of this factor is illustrated in Table 1, which shows proportions of cull fruit ranging from 8.9 to 46.3 per cent of the total quantity of fruit received. The average for all varieties of grapes and plants studied was 23.5 per cent.

Rate of Output Per Packer Hour. Output per packer hour determines the number of packing stations required for a given plant output rate,

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[1] The two types of packing lines differ slightly in the operations required of the packer. The conveyor supply equipment requires the packer to drop the empty field box from the packing position to an empty-box conveyor, while with the manual supply equipment, disposal of the empty field box is performed by the setup man. The additional packer labor required with the conveyor supply packing line is very small and is ignored in this analysis.

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A. Conveyor-supply packing-line equipment. LEFT: Delivery of field boxes to packing line on one side of conveyor aly. Field boxes are placed by hand on upper conveyor at setup station (not shown). As packer draws full field box from conveyor to sloping box stand at left, a new box is automatically moved into position by the conveyor. Culls trimmed out by the packer (see second packer from left) fall through cull chute to conveyor (not shown) near floor; empty field boxes are dropped by packer to conveyor beneath sloping field-box stand. RIGHT: Conveyor-supply equipment which feeds full field boxes to packer stations along both sides of conveyor. Note return belt for empty field boxes under inclined racks for field boxes and cross conveyor in foreground which transports empty field boxes to central point for set-off and stacking. Also, note beneath inclined field-box racks a cull conveyor leading to an overhead cull bin.

B. Manual-supply packing-line equipment. Full field boxes are transported to setup positions alongside packing line. Setup man (at left corner of picture on right) places field box on sloping rack and removes and stacks empty box. Also, with equipment not having a cull belt, setup man places and removes cull box under inclined box racks.

C. Cull disposal. LEFT: Stacks of full cull boxes are trucked from temporary storage to a dumping station where the culls are emptied onto an elevator to a highway truck and the empty boxes restacked. RIGHT: Overhead cull bin, filled by conveyor belt from packing lines and emptied by gravity chute to highway truck.

Fig. 2. Variations in equipment and methods used in the packer-supply operations for California fresh table grapes.

and this affects trucking distances, lengths of conveyors for culls and empty boxes, and the amount of building space required for the packer supply operations. Since the rate of packer output varies widely among plants--the range indicated in Table 1 is from 4.1 to 30.8 standard lugs per hour--it becomes an important factor in analyzing the costs of the packer supply operations.[1]

Size of Plant. Since the unit costs of the packer supply operation may vary as the size of plant changes, it is necessary to consider this factor in the analysis. Several definitions of size of plant might be recognized--for example, total floor area, rate of receiving incoming fruit, or rate of output of packed fruit. For this analysis, size of plant is defined in terms of the rate of output of packed lugs per hour when the plant is in full operation. On this basis, Table 1 indicates an approximate range in size of plant from 140 to 1,150 lugs per hour. The average rates in the plants packing Emperor and summer grapes were approximately 750 and 680 lugs per hour, and the average for plants packing Tokay grapes was about 300 lugs per hour.

Purpose of Report

The analysis which follows is designed to show how variations in the factors noted above affect the costs of the packer supply operations. Such information can be applied by packing house managers in the selection of equipment and methods that will reduce costs and improve efficiency.

COST-ESTIMATING PROCEDURE

Estimating the costs of the packer supply operations involves determining the quantities of equipment, labor, and other services required in relation to the volume of fruit handled, the proportion of cull fruit, and the type of

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[1] Studies of grape packing have shown rate of output to vary with variety of grape, proportion of cull fruit, and packer wage plan. Output rates decrease as per cent of cull fruit increases; with a given per cent of cull fruit, they are highest with a straight piece-rate wage plan and they are lowest with a straight hourly rate wage plan. See French, B. C., and L. L. Sammet, Wage Plans and Efficiency in Grape Packing (Berkeley: University of California, Division of Agricultural Sciences, Agricultural Experiment Station, 1954), 41p. (Giannini Foundation Mimeographed Report No. 173.) Processed.

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equipment used. These quantities can then be converted to costs through application of appropriate prices and cost rates for each item. The general bases for the quantity estimates in this report are described below. More detailed information is given in the Appendix.

Labor Requirements

The estimates of labor requirements for the packer supply operations are based on time and production studies of plant operations and analysis of accounting record data. From these data net time requirements, allowances for rest and unavoidable delay, and standard production rates were computed for each job. For example, one of the jobs in plants using the conveyor supply type of packing-line equipment is to transfer individual field boxes from a stack adjacent to the set-up station to a conveyor leading to the packers. From studies of this operation in a number of plants and from analysis of accounting record data, net labor requirements per field box transferred were estimated as 0.120 man-minutes per box, and the time used for rest and unavoidable delays as 20 per cent of the total time.1/ On this basis, the gross time per box is 0.150 man-minutes and the output rate is 400 boxes per man-hour. This is considered an "efficient" output rate in the sense that it can be achieved by average workers when fully occupied at this job. Output rates per man-hour determined in this way are defined in this report as "production standards." Time and production standards for the various jobs are summarized in Appendix Tables A and B.

Equipment and Building Requirements

The quantities of equipment required with a given method and rate of output are indicated in some instances by the labor production standards. Requirements for equipment essential in other operations and for building space are based on an analysis of plant layout and operating procedures in the plants studied. The bases of estimation for the principal items are described below.2/ More complete information is given in Appendix Tables A, B, C, and E.

1/ Scheduled rest periods, 4 per cent; the remainder, minimum unavoidable delay and personal time.

2/ The quantities specified are typical and appropriate for cost estimation in this report and for preliminary studies in a particular plant. For final design and planning, however, some modification might be required for particular situations.

Trucking equipment: One truck (hand or fork-lift type) is provided for each worker performing this operation.

Cull boxes (in plants not using cull bins): The number of cull boxes included in the cost estimates is related to the rate of cull accumulation and assumes more frequent pickup of culls as plant capacity rate increases. For example, with 30 per cent culls, the number of cull boxes provided is adequate for 16 hours of operation in small plants (output rate 200 packed lugs per hour) and for about 5 hours of operation in large plants (output rate 1,200 packed lugs per hour).[1/]

Cull bin: In plants using bin storage for culls, storage space is provided for approximately 8 hours of operation. Bin volume is estimated at the rate of 50 cubic feet per ton.

Cull belt: With the conveyor type of packer supply equipment, a cull belt is an integral part of the packing line. An additional cross conveyor is required, however, in multiline plants. If cull belts are used with the manual type of packer supply equipment, the length of in-line conveyor required is based on a spacing of 3 feet, 8 inches between packing stations. The length of the cross conveyor will range from 20 to 30 feet per packing line, depending on the type of equipment used. A minimum belt width of 10 inches is used, with the width increased at the rate of 3 1/4 inches for each 1,000 pounds of culls per hour in excess of an hourly rate of 3,250 pounds. The maximum length of conveyor per drive section is 100 feet; for longer conveyors, additional drive units are provided.

Pallets: Pallets are required if culls are stored in boxes in plants using fork-truck equipment. The number of pallets supplied is estimated at the rate of 1 pallet per 60 cull boxes.[2/]

Packing-line equipment: As previously noted, it is necessary to include packing equipment in the analysis of the packer supply operations because, with the conveyor-type equipment, some of the facilities for handling field boxes and culls are an integral part of the packing line. The number of packing stations required depends on

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[1/] Based on average net weight of 34 pounds per cull box.

[2/] Costs of pallets required for handling incoming or packed fruit or in storing or handling package materials or other supplies are not included in this analysis.

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the rate of plant output per hour and the average rate of output per packer hour. Typical plant layouts in a one-line plant are illustrated in Figure 3.

Building space: The quantity of building space required for storage of incoming fruit and culls, for the packing-line equipment, and for necessary access aisles to these areas was estimated from studies of space allocations in a sample of plants. Slightly smaller floor area requirements in fork-truck than in hand-truck plants were indicated. In general the relationships established for storage and aisle space reflect decreasing space requirements per unit of output as the size of plant increases.[1] Details as to floor space requirements are given in Appendix Table C.

Cost Categories

Two categories of costs are considered--the variable costs of labor, power, and equipment repair, and annual fixed costs for equipment. The bases of calculation are as follows:

Variable costs: While wage rates varied with respect to the individual plant and packing district, the detailed analysis which follows is based on a wage rate of $1.05 per hour, with the exception of $1.10 per hour for the fork-lift operators. For the jobs involved in the packer supply operations, these rates are typical of wages paid in packing plants in the San Joaquin Valley districts during the 1953 packing season. The wage level for this type of work was approximately 20 per cent higher in the Tokay packing district. Power costs for electric motors are estimated at the rate of 3 cents per motor horsepower per hour of operation; fuel and lubrication costs for fork-truck equipment

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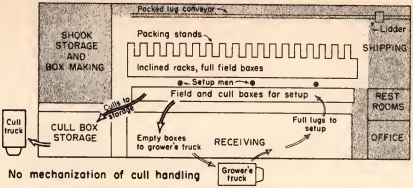
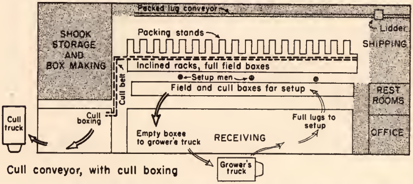
[1] In a plant of given size, space requirements for aisles will ordinarily be greater in fork-truck than in hand-truck plants, but this difference is more than offset by the reduction in storage areas resulting from double or triple tiering of pallet loads of fruit or materials in the fork-truck plants.

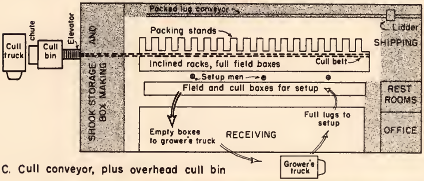
The relatively larger space requirements per unit of output in the smaller plants results from the fact that space requirements for some uses such as aisles, office, and storage are relatively greater in small than in large plants.



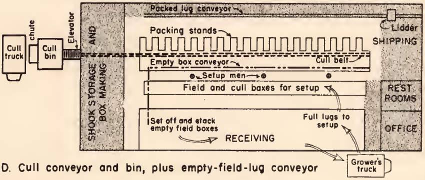
A. No mechanization of cull handling



B. Cull conveyor, with cull boxing



C. Cull conveyor, plus overhead cull bin



D. Cull conveyor and bin, plus empty-field-lug conveyor

Fig. 3. Schematic layout of a grape packing plant using manual-supply type of packing-line equipment, with four variations in methods of handling culls and empty field boxes.

(4,000 pounds capacity) are estimated as 20 cents per hour of operation.[1] Variable repair expense for equipment is estimated at the rate of 0.5 per cent of the replacement cost per 100 hours of use.[2]

Annual fixed costs of equipment: The costs of buildings and equipment having a use life extending over several seasons are included on the basis of a fixed annual charge. These costs are calculated by applying to the estimated 1953 replacement costs a percentage annual charge that includes allowance for depreciation, taxes, insurance, interest on the investment, and fixed repair expense. For details concerning the percentage rates used for different types of equipment and for buildings, see Appendix Table F.

Applicability of Cost Estimates

Since variation occurs in the performance of individual workers and in the working conditions in different plants, the production standards used to estimate labor requirements and costs in this report may not be strictly applicable in a given plant. A similar situation exists with respect to the rates for wages and other services and the estimates of equipment and building costs used in this study. However, the estimates should provide a satisfactory basis for comparison of costs with different methods. Several characteristics of the estimates support this judgment: they are designed to reflect a uniform level of efficiency

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[1] The electric power rate used approximates the rates quoted by California power companies for operations of the type carried on in packing fresh fruits. The operating costs for fork-lift equipment are developed in terms of 1950 prices which have been adjusted to the 1953 price level. See Sammet, L. L., In-Plant Transportation Costs as Related to Materials Handling Methods--Apple and Pear Packing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, January, 1953), 57p. (Giannini Foundation Mimeographed Report No. 142.) Processed.

[2] Adequate data on equipment repair costs are not available, and this necessitates a somewhat arbitrary allocation of repair expense. In the procedure outlined above, it is recognized that deterioration of equipment is a function of both time and use. Hence, part of the estimated repair expense is included as a direct charge per hour of use, while an additional fixed amount per year is included at the rate of 1.5 per cent of the replacement costs. With regard to buildings, only a fixed repair expense per year is included. The rates used reflect conclusions reached in earlier reports in this series. See Ibid. and Sammet, L. L., and I. F. Davis, Building and Equipment Costs, Apple and Pear Packing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, December, 1952), 38p. (Giannini Foundation Mimeographed Report No. 141.) Processed.

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with all methods; the labor standards reflect average performance capabilities for the industry and the wage rates used are typical of the major packing districts; the procedures used in estimating the costs of buildings and equipment are consistent for all methods.[1]

COSTS WITH DIFFERENT METHODS AND OPERATING CONDITIONS

With many significant variations in type of equipment and operating conditions, some simplification is necessary in the cost comparisons, at least in the initial stages of the analysis. The problem is approached, therefore, by developing estimates of costs with certain factors held fixed, then studying the effects on costs if these fixed conditions are modified.

Conditions Assumed in Initial Analysis

Initially, the problem is organized along the following lines:

Hand-truck versus fork-truck equipment: An important difference in method of performing the packer supply operations is the type of equipment used for in-plant transportation of incoming fruit and culls. The use of fork-truck rather than hand-truck equipment reduces labor and building space requirements but involves increased costs for equipment and pallets. Comparisons of the costs of the packer supply operations in the two types of plants indicate that, with a given procedure for handling incoming fruit and culls and for the lengths of operating season considered, costs are not greatly different with the two types of trucking equipment. Moreover, relative costs among the different methods of performing the packer supply operations are essentially the same regardless of whether hand trucks or fork trucks are used. For these reasons, and because hand-truck equipment is the type most commonly used, the following analysis is based on the use of hand trucks in the packer supply operation.[2]

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[1] The labor standards include an allowance for rest and for a minimum of unavoidable delay.

[2] To compare costs with hand-truck and fork-truck equipment correctly requires study of the entire plant operation. The results of such a study will be presented in a later report. In general, the use of fork-truck equipment will prove more economical as length of season increases. Data concerning labor and equipment requirements and costs with fork-truck equipment are given in Appendix Tables A to E. A summary of cost relationships with this type of trucking equipment is given in Appendix Table I.

Output and culling rates: Costs of the packer supply operations are first estimated on the basis that 30 per cent of the total fruit received is trimmed out as culls, while the rate of packer output is taken as 10 lugs per packer hour. Rates of plant output through the range of 100 to 1,200 lugs per hour of plant operation are considered.[1]

Variation in handling methods and equipment: With the conditions specified above, costs with the two types of packing-line equipment and several degrees of mechanization with each type of equipment are considered. These are illustrated in schematic floor plans for a one-line packing house using the manual supply type of packing-line equipment (Figure 3). Four different methods of cull and empty field box handling are shown: Method A, which applies only to the manual supply type of packing-line equipment and involves no mechanization in the handling of culls and empty field boxes; Method B, in which a cull belt is added to the manual supply packing-line equipment, thus placing the two types of packing-line equipment on a comparable basis with respect to cull handling methods; Method C, which involves the addition of a cull elevator and overhead cull bin to both types of packing-line equipment; and Method D, in which a conveyor system for empty field boxes is added to both types of packing-line equipment.[2] The operations performed with these methods are described in more detail in Table 2 and are illustrated in Figure 2.

Estimated Costs of Packer Supply Operations

Estimates of the costs of the packer supply operations which follow are based on the production standards developed for each job and on engineering estimates of equipment requirements and costs. An example is given in Table 3

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[1] Output rates are expressed in terms of packed standard display lugs.

[2] With the above methods, the conveyor supply packing-line equipment includes a conveyor which transports empty field boxes from the packing stations to a point at the end of the line near the setup station. With this arrangement, the empty-box conveyor considered in Method D collects boxes from adjacent lines and delivers them to a single point for setoff and stacking. With the manual-type packing line, a similar arrangement is necessary plus the addition of empty-box conveyors over each packing line.

TABLE 2

Variations in Handling Methods for Fruit and Materials in Packer Supply Operations in Packing Fresh Table Grapes

Method	Type of packing-line equipment	
	Manual supply	Conveyor supply
A. No mechanization of cull handling	Incoming fruit: Transport to temporary storage, then to setup at packing stations. Set up full field lug at packer station; stack empty lug on floor; return empty lugs to grower's truck. Culls: Set up empty cull box at packer station; remove full cull box and stack on floor. Transport culls to temporary storage, then to cull truck. Empty cull boxes in truck, return empty boxes to packing line.	This method not used with conveyor supply equipment.
B. Cull conveyor with cull boxing	Same as above, except that culls are transported by conveyor to a central cull-boxing station.	Incoming fruit: Transport to temporary storage, then to setup station at end of packing line. Set up full field lug at end of packing line; pick up empty field lug returned by conveyor from packing stations and stack on floor; return empty lugs to grower's truck. Culls: Place empty cull box at cull conveyor; remove and stack full boxes. Transport cull box to temporary storage, then to cull dumping station. Dump cull boxes in truck; return empty boxes to cull-boxing station.
C. Cull conveyor plus overhead cull bin	Same as above, except that culls are delivered by conveyor to an overhead cull bin. Bin periodically emptied by gravity chute to cull truck.	Same as above, except that culls are delivered by conveyor to an overhead cull bin. Bin periodically emptied by gravity chute to cull truck.
D. Cull conveyor and bin, plus empty field box conveyor	Same as Method C, except that empty field lugs are transported from packing stations by conveyor to a central point where they are stacked, transported to temporary storage, and later loaded on the grower's truck.	Same as Method C, except that empty field lugs are delivered by conveyor from the end of the packing line to a central point where they are stacked, transported to temporary storage, and later loaded on the grower's truck.

TABLE 3

Estimated Variable and Fixed Costs of Packer Supply Operations in a Grape Packing Plant of 600 Lugs Per Hour (Packed) Capacity in Which Culls are 30 Per Cent of Total Fruit Run, Packer Output Rate is 10 Lugs Per Packer Hour, and Manual Supply Type of Packing Line with Hand-Truck Equipment is Used (Method A), California, 1953[a]

Variable costs of labor and equipment		Replacement and annual fixed costs of equipment			
Item	Cost per hour	Item and amount required	Annual charge[b]	Replacement cost	Annual fixed cost
	dollars		per cent	dollars	
LABOR[c]		EQUIPMENT			
Hand-truck field boxes from grower's truck to temporary storage, then to setup; return empty lugs to grower's truck: Number of field boxes per hour, 800; production standard, 230 boxes per man-hour. Number of truckers required, 4. Cost at $1.05 per hour.	4.20	Hand truck: One per trucker at $84.00 each.	13.2	420	55
Hand-truck boxed culls to temporary storage, then to highway truck; hand dump culls into truck; return empty cull boxes to setup station: Number of cull boxes per hour, 206; production standard, 315 cull boxes per man-hour. Number of cull handlers required, 1. Cost at $1.05 per hour.	1.05	Cull boxes: 1,640 boxes at $0.90 each.[d]	16.5	1,475	243
Setup field and cull boxes for packers: 800 field boxes and 206 cull boxes per hour; production standard, 145 boxes per hour. Number of setup men required, 7. Cost at $1.05 per hour.	7.35	Packing and setup stands: 60 stands at $33.00 each.	13.2	1,980	261
		BUILDING SPACE Total floor area in plant, 14,160 square feet; unit cost, $2.14 per square foot. Cost of 7,970 square feet used in packer-supply operations.[e]	10.0	17,055	1,705
Total labor cost per hour	12.60	TOTAL, EQUIPMENT AND BUILDINGS		20,930	2,264
Equipment repair: Estimated at 0.5 per cent of replacement cost per 100 hours use.[f]	.19				
TOTAL VARIABLE COST PER HOUR	12.79				

[a] For details of production standards and equipment requirements and costs, see Appendix Tables A to E.

[b] See Appendix Table F for breakdown.

[c] The number of field and cull boxes handled are computed from the packout rate on the following basis: Culls amount to 30 per cent by weight of the total fruit run. Container net weights are: packed lug, 28 pounds; field box, 30 pounds; cull box, 34 pounds.

[d] This quantity of cull boxes provides storage for an eight-hour run.

[e] Space requirements and costs are based on a hand-truck plant, using wood-frame construction. For details on estimating procedure, see Appendix.

[f] In addition to estimated repair expense per hour of operation, an allowance of 1.5 per cent of replacement cost is included to cover repair costs related to time rather than use.

for a hand-truck plant using manual supply equipment and packing 600 lugs per hour, with 30 per cent of the fruit received trimmed out as culls. Packer output rate is 10 boxes per packer hour. Details of the estimating procedure are given in the Appendix.

For the operating conditions specified, the estimated annual fixed costs of equipment and building space are indicated in Table 3 as $2,264. The variable costs of equipment repair are given as 19 cents per hour, labor costs as $12.60 per hour, and total variable costs as $12.79 per hour. Similar estimates for other rates of plant output and other work methods are summarized in Table 4.

Table 4 shows the increase in annual fixed costs for equipment that results from increased mechanization. This partially offsets savings realized with some methods through reduction in total variable costs. In fact, with short-season operation, increased mechanization may prove uneconomical despite savings in variable costs.

Since length of packing season is an important factor, comparisons of costs with different methods can best be made in terms of total costs per season. Total variable costs per season may be estimated by multiplying the variable costs per hour in Table 4 by the hours of operation per season. This amount plus the annual fixed costs of equipment and building space gives an estimate of the total cost per season.

How total season costs with a given method vary as size of plant increases is illustrated in Figure 4, in which costs with manual supply packing-line equipment and nonmechanized cull handling (Method A) are shown in relation to size of plant. Three lengths of season (250, 500, and 750 hours of operation per season) are considered, and the data in Table 4 are supplemented to provide estimates of total season cost at plant-capacity intervals of 100 packed lugs per hour. As shown in Figure 4, total season costs computed for specific levels of plant capacity rise in a slightly irregular fashion as plant capacity increases. This irregularity reflects the fact that labor and equipment are added in sizeable units as plant capacity is increased.

A relationship in which total season costs vary uniformly as size of plant changes can be represented by the straight lines "smoothed" through the three groups of points in Figure 4. Average relationships of this type give a good representation of how total season costs vary with plant output rate and are convenient for comparing costs with different methods. They are used in the discussion which follows.

TABLE 4

Variable Costs Per Hour and Annual Fixed Costs of Equipment for Packer Supply Operations in Relation to Rate of Plant Output and Type of Equipment and Methods Used in a Hand-Truck Plant with Packer Output Rate Ten Lugs Per Packer Hour and 30 Per Cent Culls Packing Fresh Table Grapes, California, 1953

Method	Plant output rate, packed lugs per hour[a]	Type of packer supply equipment			
		Manual		Conveyor	
		Variable cost per hour[b]	Annual fixed cost[c]	Variable cost per hour[b]	Annual fixed cost[c]
		dollars			
A. No mechanization of cull handling	200	5.32	1,190	This method not used	
	400	8.53	1,725		
	600	12.79	2,264		
	800	17.04	2,737		
	1,000	21.28	3,207		
	1,200	25.53	3,687		
B. Cull conveyor, with cull boxing	200	5.40	1,376	5.72	2,069
	400	9.74	2,220	9.14	3,065
	600	14.08	3,029	11.70	4,550
	800	18.42	3,831	17.21	5,552
	1,000	23.81	4,661	20.80	6,912
	1,200	28.13	5,340	23.17	7,892
C. Cull conveyor, plus overhead cull bin	200	4.60	1,568	3.87	2,261
	400	8.04	2,510	6.39	3,355
	600	11.48	3,401	9.10	4,922
	800	14.94	4,336	13.73	6,057
	1,000	19.44	5,299	17.49	7,550
	1,200	22.88	6,111	18.97	8,663
D. Cull conveyor and bin, plus empty field lug conveyor	200	5.70	1,675	3.92	2,369
	400	9.24	2,833	6.45	3,496
	600	13.79	3,865	9.18	5,096
	800	17.31	4,940	12.77	6,264
	1,000	22.93	6,043	17.60	7,790
	1,200	26.37	6,855	19.08	8,903

a/ Standard display lug, 28 pounds net weight.

b/ Includes costs of labor, power, and variable equipment repair expense. See Appendix for details.

c/ Includes depreciation, interest, taxes, insurance, and an allowance for repair expense related to time. See Appendix Table F for details.

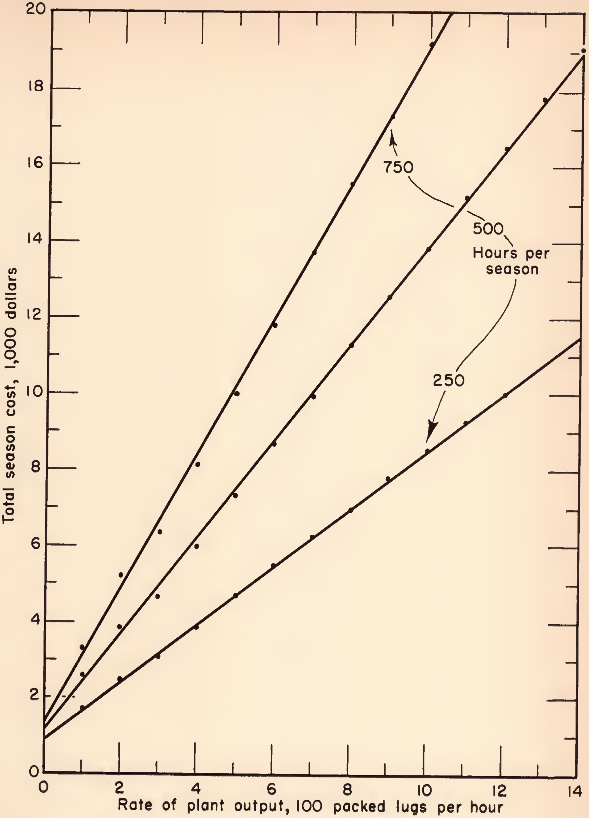

Fig. 4. Total season costs of the packer-supply operations in relation to rate of plant output and hours of operation per season. The costs apply to a hand truck plant using manual-supply packing-line equipment and nonmechanized cull-handling methods, with culls 30 per cent of the total fruit run and rate of packer output 10 lugs per packer hour. California grape packing, 1953.

Comparison of Costs with Different Methods

Following a procedure similar to that described in the development of Figure 4, estimates of total season costs with other methods can be made. Such estimates are given in Figure 5 for both the conveyor and manual type of packing-line equipment. As in the preceding development, the costs shown are based on a packer output rate of 10 boxes per hour and a culling rate of 30 per cent of the total quantity of fruit run. Comparison of costs with different methods as shown in Figure 5 indicates the following.

1. With a given length of season, total costs per season with all methods increase as the size of plant increases. On the other hand, average unit costs decrease as size of plant increases. Minor changes in relative costs with different methods occur as the size of plant varies, but this effect is not significant except in very small plants.
2. With the manual supply type of packing-line equipment and 250 hours of operation per season, Method A (in which the in-plant transportation of culls and empty field boxes is performed with hand trucks) is lowest in cost. Method C is lowest in cost with a long season of 750 hours operation, although the difference in cost between Methods A and C is not large. With the conveyor supply type of packing-line equipment and 250 hours of operation per season, total costs with all three methods of cull and empty field box handling do not differ greatly through the range of plant sizes shown. With a long operating season--for example, the 750-hour season shown--total season costs with Methods D and C are nearly the same through the range of plant sizes studied; in large plants, costs with Methods C and D are substantially less than with Method B.
3. If the low-cost methods with both types of packing-line equipment are compared by means of chart readings for given plant sizes (Figure 5), costs with the manual supply type of packing-line equipment are substantially less than with the conveyor supply equipment. For example, the chart indicates that--with 250 hours' operation per season, and a plant output rate of 600 packed lugs per hour--the least cost ($5,500) occurs with the manual supply type of packing-line equipment, using Method A for cull and empty field box handling. With the conveyor supply type of packing-line equipment, the comparable total season cost is $7,400 (Method C). With the same output rate per plant

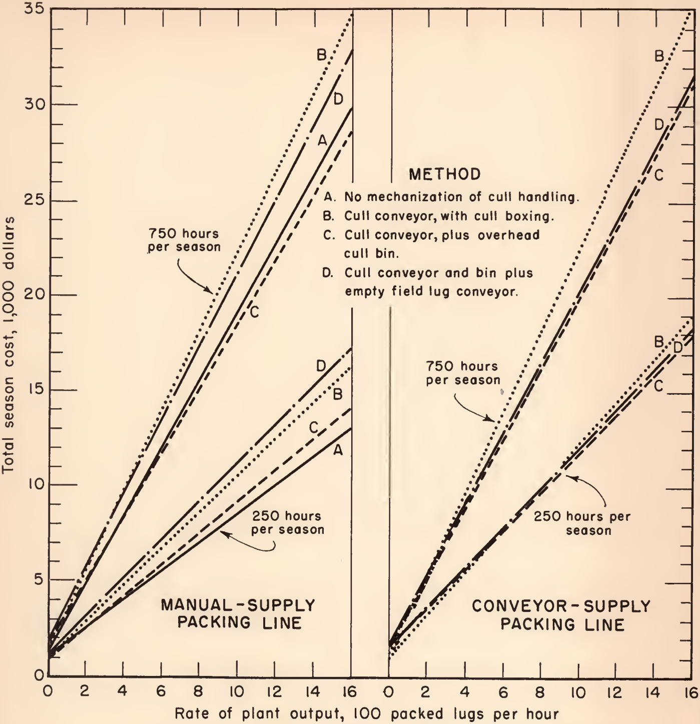

Fig. 5. Total season costs of the packer-supply operations in relation to size of plant, type of packing-line equipment, method of handling culls and empty field boxes, and length of operating season. The costs apply to a hand truck plant in which culls are 30 per cent of the total fruit run and packer output rate is 10 lugs per packer hour.

hour, but a season operation of 750 hours, these costs increase to $11,500 with the manual supply type of packing-line equipment and $12,400 with the conveyor supply type of packing-line equipment. While the cost level is higher with the longer season, the difference in costs with the two types of equipment is much less than with the short-season operation.

Effect of Packer Output Rate on Cost Comparisons

The costs of the packer supply operations shown in Figure 5 vary as rate of packer output changes. With an increase in output per packer hour, for example, fewer packers would be required for a given rate of plant output. As a result, fewer packing stations, less building space, and shorter conveyors for culls or empty boxes would be required, and the costs of these items would be reduced accordingly. If a lower rate of packer output were considered, increased costs for these items would result.

The effects of differences in the rate of packer output on costs are illustrated in Figure 6 in which total season costs with manual- and conveyor-type packing lines are given for 30 per cent cull fruit and four rates of packer output--5, 10, 20, and 30 boxes per packer hour.[1] The charts indicate that, with size of plant given, total season costs of the packer supply operations decrease as output per packer hour increases. These effects are also shown in Table 5 which summarizes chart readings for the low-cost method in plants of 600-lugs-per-hour capacity.

Table 5 indicates a shift in relative costs with different types of packing-line equipment and cull handling methods as the rate of packer output per hour and length of operating season change. With the manual supply packing-line equipment and a short packing season, for example, Method A is lowest in cost for all rates of packer output shown, as well as with a long operating season and low packer output rates. But with a packer output rate of 10 lugs of more per hour, Method C--in which culls are disposed of via a cull conveyor and overhead bin--is lowest in cost. With the conveyor-type packing-line equipment,

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[1] This range in packer output rates is feasible with 30 per cent cull fruit and appropriate combinations of variety of grape and packer wage plans. With some combinations of grape variety and packer wage plans, and with higher cull proportions, a narrower range in packer output rate is applicable.

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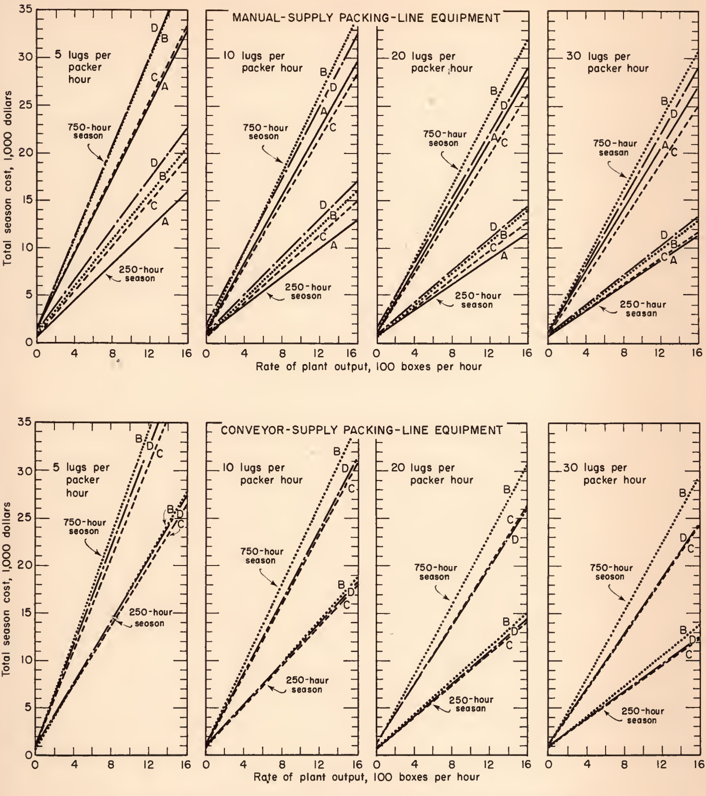

Fig. 6. Total season costs of the packer-supply operation in relation to type of equipment used, rate of plant and packer output per hour, and method of handling culls and empty field boxes. The costs apply to hand truck plants, with 30 per cent cull fruit. California grape packing, 1953.

TABLE 5

The Effect of Rate of Packer Output, Type of Packing-Line Equipment, and Hours of Operation on Total Season Costs of the Packer Supply Operations Using the Most Economical Method with a Given Rate of Packer Output (Plant Output Rate, 600 Packed Lugs Per Hour; Culls, 30 Per Cent of Total Fruit Run) Packing Fresh Table Grapes, California, 1953

Hours of plant operation per season	Packer output, lugs per packer hour	Manual supply packing-line equipment		Conveyor supply packing-line equipment	
		Method	Total season cost	Method	Total season cost
			1,000 dollars		1,000 dollars
250	5	A	6.5	C	10.5
	10	A	5.5	C	7.3
	20	A	5.0	C	5.9
	30	A	4.9	C	5.2
750	5	A	13.2	C	15.9
	10	C	11.5	C	12.3
	20	C	10.6	C	10.6
	30	C	10.3	C	9.9

Method C is lowest in cost for the entire range of operating conditions considered; and with long-season operation and high rates of packer output, costs with the conveyor supply type of packing line are less than with the manual supply type of equipment.

Effect of Proportion of Cull Fruit on Costs

As the proportion of cull fruit increases, the quantity of fruit handled for a given packout increases rapidly. For example, when culls are 15 per cent of the total fruit run, 110 average weight field boxes of fruit are required per 100 packed lugs, while 170 field boxes are required per 100 lugs with 45 per cent culls. The greater quantity of materials handled as the proportion of culls increases results in increased costs for the packer supply operations. This is shown in Figure 7 which gives total season costs in a plant of 600-lugs-per-hour capacity with rate of packer output, 10 lugs per packer hour.[1] Costs are shown for manual supply and conveyor supply packing-line equipment and for the various methods of handling culls and empty field boxes. In these, and similar relationships for other rates of packer output, it is important to note that unlimited variation in the proportion of culls and rate of packer output within the ranges shown is not feasible. Only appropriate combinations of cull and packer output rates in relation to variety of grape and packer wage plan should be considered.[2] The charts indicate the following:

1. Costs rise sharply as the proportion of cull fruit increases; the rise is steeper with methods involving manual handling of culls in boxes (Methods A and B) than with mechanical handling of culls (Methods C and D).
2. Mechanical cull handling becomes more economical as the proportion of cull fruit increases (compare Methods C and D with Methods A and B).
3. Mechanical cull handling becomes more economical as the length of season increases. With a manual supply packing line and 250 hours' operation per season, for example, Method A is lowest in cost, although

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[1] Relative costs with different cull handling methods vary as the plant capacity changes. However, Figures 5 and 6 indicate that there are no important shifts in position of the various methods as plant size changes. Comparisons at the particular plant-capacity rate shown, therefore, give a good indication of the effects of variation in proportion of cull fruit costs.

[2] See French, B. C., and L. L. Sammet, Wage Plans and Efficiency . . .

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[illegible]

[illegible]

[illegible]

- a. [illegible]
- b. [illegible]
- c. [illegible]

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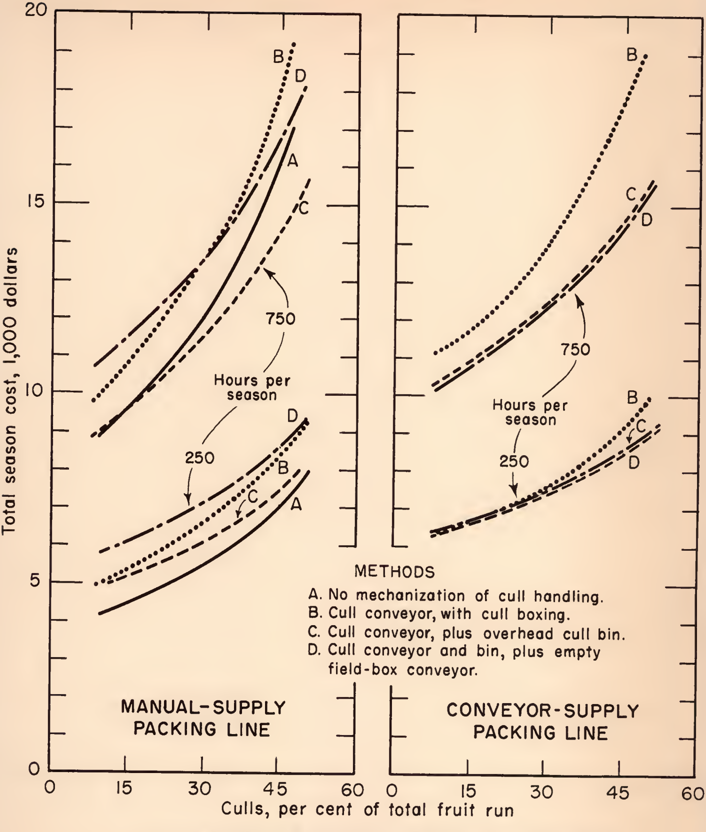

Fig. 7. Total season costs of packer-supply operations in relation to type of equipment used, proportion of cull fruit, and method of handling culls and empty field boxes in a plant of 600-lugs-per-hour capacity and rate of packer output 10 lugs per packer hour. The costs are for plants using hand truck equipment. California grape packing, 1953.

the cost advantage of this method decreases as the proportion of culls increases. With 750 hours of operation per season, mechanized cull handling (Method C) is lowest in cost for cull proportions exceeding approximately 15 per cent. A similar situation applies with the conveyor supply packing-line equipment. With 250 hours' operation, Method C is lowest in cost for the range of cull proportions considered, while Method D is lowest in cost with the longer season. The cost advantage of both Methods C and D relative to Method B increases as hours of operation per season increase.

Selection of Most Economical Method

In the preceding cost comparisons, the effects of rate of packer output and proportion of cull fruit are considered separately but with restrictions noted as to the appropriate combinations of values within the ranges of operation conditions shown. This is important because cull and packer output rates are not independent. The studies of grape packing previously referred to show that rates of packer output decline rapidly as the proportion of cull fruit rises, that output rates vary widely among the different wage plans used, and that they differ according to the variety of grape packed. The nature of these relationships, developed in a previous report, are illustrated in Table 6, which summarizes the range in output rates with different wage plans that might be expected with three categories of variety of grape and three different proportions of cull fruit.[1/]

Table 6 indicates that with summer grapes average output rates per packer hour might be expected to fall between 5 and 11 lugs per packer hour when culls are 15 per cent and between 3 and 7 lugs per packer hour with 45 per cent culls. Similar ranges for Emperor grapes are 7 to 22 lugs per packer hour with 15 per cent culls and 4 to 14 lugs per packer hour with 45 per cent culls. In some plants, packer output rates in relation to cull proportions were considerably outside the range in average rates indicated in Table 6.

[1/] See French, B. C., and L. L. Sammet, Wage Plans and Efficiency . . ., which also shows to a limited extent (page 16) how variety of grape, wage plan, and proportion of culls affect the combined costs of packing labor and the packer supply operations.

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TABLE 6

The Effect of Variety of Grape, Packer Wage Plan, and Proportion of Culls on the Range in Average Packer Output Rates in Packing Fresh Table Grapes, California[a]

Varietal group	Packer wage plan[b]	15 per cent culls[c]	30 per cent culls[c]	45 per cent culls[c]
		standard lugs per packer hour		
Summer grapes[d]	Hourly	4.8	4.0	3.1
	Incentive	11.3	9.3	7.3
Tokay	Hourly	10.0	8.3	6.5
	Combination	12.7	10.4	8.2
Emperor	Hourly	7.0	5.7	4.5
	Incentive	21.8	18.0	14.1

a/ Output rates estimated in terms of standard lugs (28 pounds net weight) from accounting records of packout and packer labor utilization in sample plants. See, French, B. C., and L. L. Sammet, *Wage Plans and Efficiency in Grape Packing* (Berkeley: University of California, Division of Agricultural Sciences, Agricultural Experiment Station, 1954), 41p. (Giannini Foundation Mimeographed Report No. 173.) Processed.

b/ Hourly wage plan--flat rate per hour; incentive plan--straight piece rate per lug; combination--hourly rate plus piece rate. With each variety of grape, output rates between the extremes shown were associated with various wage plans involving a composite of straight incentive and hourly rate wage plans.

c/ Per cent of total fruit run.

d/ Data were primarily for packing Thompson grapes, with some Red Malaga and Ribier.

It is clear from Table 6 that application of the preceding cost data must give consideration to the limitations to packer output rates associated with variety of grape, proportion of culls, and packer wage plan. These limitations are important in studying the data in Table 7 which gives total season costs in a plant of 600-lugs-per-hour capacity with short-season operation (250 hours) and long-season operation (750 hours).[1/] Costs are shown with rates of packer output ranging from 5 to 30 lugs per packer hour and with cull proportions of 15, 30, and 45 per cent.

Table 7 is so arranged that each "cell" presents costs with the various types of equipment and handling methods, and for given levels of packer output rates, proportions of culls and lengths of operating season. In each cell, the figure for the low-cost method is underlined. The cell at the lower right corner of each set of data (representing rate combinations of 45 per cent cull fruit and 30 lugs per packer hour) is blank. Data for this cell are omitted because a packer output rate at this high level is impracticable with the high rate of culling. The rate combinations with the remaining cells could be achieved, or approached closely, in plants where operating conditions reflect cull and packer output rates approximating those specified.

A shipper whose operating conditions approximate 250 hours' operation per season, with 15 per cent culls, a packer output rate of 5 lugs per packer hour, and a plant output rate of 600 lugs per hour, would find comparisons of total season costs with different methods in the "cell" at the upper left corner of Table 7. This indicates that, for the operating conditions specified, the manual supply packing-line equipment gives lower costs with all methods than does the conveyor supply packing line. Of the alternative methods with the manual supply packing line, costs with Method A (no mechanization of cull or empty field box handling) are approximately $2,600 per season less than with the high-cost method (Method D). Comparing the low-cost methods with the manual and conveyor supply packing-line equipment indicates costs with the manual supply packing line to be lower by about $4,300 per year.

[1/] While the unit costs of the packer supply operations vary with size of plant, relative costs with different methods do not change greatly as size of plant varies. Hence, these cost comparisons at the single rate of 600 lugs per plant hour give a good indication of relative costs with different methods over a fairly broad range in plant size.

TABLE 7

Total Season Costs of Packer Supply Operations in Relation to Type of Equipment Used, Proportion of Cull Fruit, Rate of Packer Output, and Methods of Handling Culls and Empty Field Boxes in a Plant with an Output Rate of 600 Packed Lugs Per Hour Packing Fresh Table Grapes, California, 1953

Culls, per cent of total run	Type of equipment used: Packer supply, culls and empty field boxes	Lugs per packer hour							
		5		10		20		30	
		Manual	Conveyor	Manual	Conveyor	Manual	Conveyor	Manual	Conveyor
		Total season cost, 1,000 dollars							
		250 hours' operation per season							
15	A	5.5	--	4.5	--	4.0	--	3.9	--
	B	7.0	9.8	5.4	6.7	4.6	5.2	4.4	4.7
	C	6.8	9.8	5.2	6.6	4.4	5.1	4.1	4.7
	D	8.1	10.3	6.1	6.7	5.1	5.3	4.8	4.8
30	A	6.5	--	5.5	--	5.0	--	4.9	--
	B	8.2	10.8	6.6	7.6	5.8	6.2	5.4	5.7
	C	7.8	10.5	6.1	7.3	5.3	5.9	5.0	5.2
	D	9.2	11.0	7.1	7.5	6.1	6.0	5.8	5.3
45	A	8.0	--	7.1	--	6.6	--	a/	a/
	B	10.2	12.6	8.4	9.2	7.6	8.1	a/	a/
	C	9.2	11.8	7.5	8.5	6.7	7.1	a/	a/
	D	10.7	12.1	8.6	8.6	7.6	7.2	a/	a/
		750 hours' operation per season							
15	A	10.6	--	9.6	--	9.0	--	8.9	--
	B	12.6	15.3	10.8	11.7	10.0	10.0	9.7	9.5
	C	11.4	14.5	9.6	10.9	8.8	9.1	8.5	8.6
	D	13.7	15.5	11.5	10.8	10.4	9.3	10.1	8.8
30	A	13.2	--	12.0	--	11.4	--	11.3	--
	B	15.5	17.5	13.6	13.9	12.8	12.2	12.0	11.8
	C	13.3	15.9	11.5	12.3	10.6	10.6	10.3	9.9
	D	15.9	16.9	13.6	12.5	12.5	10.8	12.2	10.0
45	A	17.1	--	16.1	--	15.6	--	a/	a/
	B	20.1	21.8	18.2	17.9	17.3	16.6	a/	a/
	C	16.2	18.6	14.3	14.5	13.4	13.1	a/	a/
	D	19.1	18.8	16.7	14.7	15.6	13.1	a/	a/

a/ No data are given in these cells because an output rate of 30 lugs per packer hour with any of the varieties of grape and wage plans studied is unlikely when culling rates are as high as 45 per cent. The rate combinations in other cells, however, can be attained or approached closely with appropriate combinations of packer wage plan and proportion of cull fruit. For details as to packer output rates, see French, B. C., and L. L. Sammet, Wage Plans and Efficiency in Grape Packing (Berkeley: University of California, Division of Agricultural Sciences, Agricultural Experiment Station, 1954), 41p. (Giannini Foundation Mimeographed Report No. 173.) Processed.

Comparisons similar to the above can be made for other levels of packer output rates and cull proportions. These reveal a shift in low-cost method as packer output rates, proportion of culls, and length of season increase. If the point of comparison is shifted to the "cell" corresponding with 750 hours' operation per season, 45 per cent culls, and a packer output rate of 20 lugs per hour--the conveyor supply packing-line equipment gives the lowest costs.

Cost comparisons in other "cells" in the table show a gradual shift as to the low-cost method as the packer output rate and proportion of cull fruit increase. With long-season as compared with short-season operation, the break-even point between highly mechanized and nonmechanized procedures occurs with lower culling and packer output rates. With both long- and short-season operation, there appears to be a fairly broad range near the break-even point in which costs with the various methods are not greatly different.

The shift in relative costs with the different packer supply methods described above results from: (1) a decrease in the costs of the packing-line and cull-handling equipment as rate of packer output increases; (2) a less rapid increase in the fixed costs of cull-handling equipment than in the variable costs of cull-handling labor as the proportion of culls increases; and (3) lower variable costs per hour with some of the mechanized methods, which eventually offset the higher annual fixed costs of the mechanized methods as length of season increases.

SUMMARY

Studies of operations in plants packing fresh California grapes show a wide range in operating conditions. Length of season varied from approximately 3 to 16 weeks per year; size of plant from a capacity rate of about 140 to 1,150 standard lugs packed per hour; season average proportion of cull fruit from 9 to 46 per cent of the total fruit run; and season average rate of packer output from 4 to 31 lugs per packer hour.

The costs of the packer supply operations--defined in this report as receiving and transporting incoming fruit and return of empty field boxes to the highway truck, setting up fruit for the packers, and handling cull fruit--are affected significantly by variations in the above factors and in the methods and type of equipment used.

The ranges in costs that might be expected under given methods and operating conditions are summarized in Figure 8. The costs, given in this chart in cents per standard packed lug, are based on the total season cost relationships of the type summarized in Table 7.[1/] Costs in relation to per cent of cull fruit are presented for short-season (250 hours) and long-season (750 hours) operation and for small-, average-, and large-size plants (300-,600-, and 1,200-packed-lugs-per-hour capacity). In each chart reflecting specific combinations of length of season and size of plant, cost curves are presented which show the range in costs associated with variation in method and rate of packer output. The upper pair of curves in each chart shows the range in costs with the high- and low-cost methods and a packer output rate of 5 lugs per packer hour, while the lower pair of curves gives similar relationships with a packer output rate of 30 lugs per packer hour. As noted in regard to Table 7, unlimited variation in the proportion of culls and rate of packer output is not feasible. This limitation is reflected by the dotted portion of the curves for output rates of 30 lugs per

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[1/] Development of the curves in Figure 8 involved the use of three tables of total season costs--Table 7, which is for plants of 600-lugs-per-hour capacity, and similar tables (not included in this report) for plant output rates of 300 and 1,200 lugs per hour. From these data average costs per packed lug were computed for selected combinations of plant size, length of season, per cent of culls, and rate of packer output. The curves shown in Figure 8 represent traces of average unit costs in relation to per cent of culls computed in this manner for the high- and low-cost methods and packer output rates of 5 and 30 lugs per packer hour. The "kinks" in several of the curves for the low-cost methods reflect a change in curvature and level of costs resulting from the shift to a different method as the proportion of culls varies.

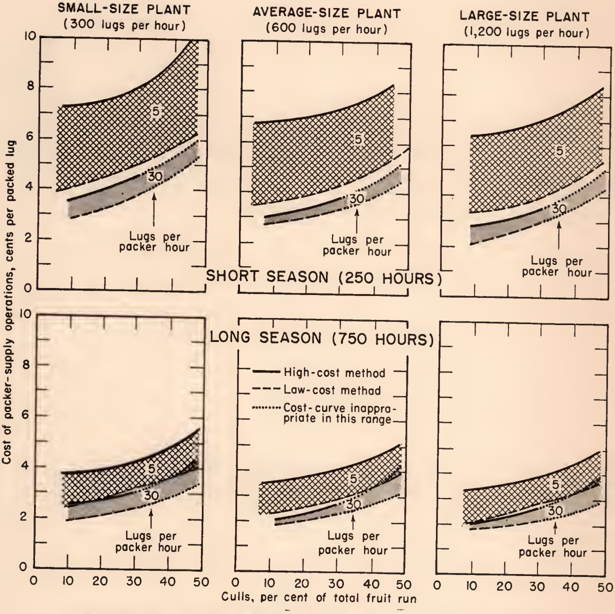

Fig. 8. The ronge in packer-supply costs per packed lug in relation to size of plant, proportion of cull fruit, output per packer hour, ond type of equipment ond methads used. Californio grape packing, 1953.

packer hour. With high proportions of culls, this rate of packer output ordinarily would not be attained, and cost estimates are not meaningful for rate combinations in the dotted portions of the curves.

The charts in Figure 8 are designed to show the approximate range in the costs of the packer supply operations to be expected in plants of different size, operating under different conditions. The charts are not intended, however, to suggest that proportion of cull fruit, packer output rates, and hours of operation per season can be varied freely by an individual packer within the ranges in operating conditions shown. The proportion of cull fruit with a given variety of fruit varies among different producers and seasons, while average packer output rates with a given variety are determined jointly by the proportion of cull fruit and the packer wage plan used.

In general, only limited variation in the factors affecting the proportion of cull fruit and packer output rates is possible for individual shippers. Some adjustment in proportion of cull fruit might be attained through changes in cultural, picking, or marketing practices. Increased packer output rates might be achieved in some plants through adoption of an incentive packer wage plan. In some areas, size of plant and hours of operation per season might be increased through consolidation of small plants. Such changes, however, would ordinarily involve shifts through only a part of the range in operating conditions shown. In this respect, Figure 8 represents the variations in costs associated with a wide range in operating conditions observed in the industry rather than an indication of the range in cost reduction possibilities open to individual shippers. These possibilities for an individual shipper would ordinarily cover a narrower range and would depend on his present situation and the nature and magnitude of the adjustments open to him.

Despite the above limitations, Figure 8 gives approximate indications of how costs of the packer supply operations may be affected by changes in operating conditions and methods. Some of these effects are noted below.

1. Size of plant. For a given length of season and proportion of culls, the costs of the packer supply operations decrease as the size of plant increases. For example, with 250 hours of operation per season, a packer output rate of 5 lugs per hour, and 30 per cent culls, costs with the low-cost method are about 5 cents per lug in the small plant, 4-1/4 cents per lug in the average-size plant, and 4 cents per lug in the large plant. A similar, although smaller, effect is evident with long-season operation.

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2. Packer output rate. When the low-cost methods at output rates of 5 and 30 lugs per packer hour are compared, the effect of the increased output per packer hour is a reduction in costs of about 1 cent per lug when the length of season is 250 hours and 1/4 to 3/4 cent per lug, depending on the proportion of culls, when the season length is 750 hours. (Note, however, that the higher range in packer output rate is not likely to be attained when cull proportions are high. This limitation accounts for the dotted portions of the curves in Figure 8.)
3. Proportion of cull fruit. Comparing the low-cost methods at output rates of both 5 and 30 lugs per hour, costs with 250 hours' operation per season increase about 1 cent per lug as culls increase from 10 to 30 per cent; and there is an additional 1-1/2 cents increase as culls rise from 30 to 50 per cent. With 750 hours' operation per season, the variation in costs as the proportion of culls changes is less regular but approximates 1/2 cent per lug as culls increase from 10 to 30 per cent and an additional 1 cent per lug as culls increase from 30 to 50 per cent.
4. Length of season. Comparing the low-cost methods at a culling rate of 30 per cent, costs with short-season operation (250 hours per season) are about 1-3/4 cents per lug higher than with long-season operation (750 hours per season). At 10 per cent culls, this difference is 1-1/2 cents, and at 50 per cent culls, it is about 2 cents per lug.
5. Method and equipment. With 250 hours' operation per season, the difference in cost between the high- and low-cost methods at a packer output rate of 5 lugs per packer hour is about 3 cents per lug throughout the range of plant size and variation in proportion of culls considered. At a packer output rate of 30 lugs per hour, this difference is only 1/4 to 3/4 cent per lug. With 750 hours' operation, similar, although smaller, cost differences occur.

The savings potential in some plants undoubtedly is substantial. Some of the changes involved would affect the costs of other operations. The costs of packer labor would be affected by the change in wage plan necessary to achieve the adjustment in rate of packer output; changes in practice necessary to reduce the proportion of packing house culls probably would affect picking, hauling, and cultural costs. A complete analysis, therefore, would require consideration of these factors.

APPENDIX

In the foregoing, the various methods and equipment used in the packer supply operations of California fresh grape packing houses have been described. The results of an analysis of the costs of these operations have been presented but with little attention to the computational methods or basic data used. This Appendix contains a summary of the data on which the analysis is based. These data may be used by those who wish to follow in more detail the results given in the report or by packing house managers interested in specific studies of their own operations.

The quantities of equipment, building space, and labor specified in relation to output rates were derived through analysis of actual operations and space and equipment layout in the plants studied, and they are intended to reflect average requirements under efficient organization. The replacement costs of equipment and buildings were developed through detailed engineering estimates, from recent purchase data in plant accounting records, and interviews with equipment manufacturers and suppliers. The quantity and cost relationships are appropriate for estimation in this report and for preliminary studies in particular plants. For final design and planning, however, some modification might be required for particular situations.

Labor Requirements

Production and time standards for the jobs performed in the packer supply operations are summarized in Tables A and B . The standards are based on net unit time requirements for specific operations as determined by time and production studies of actual plant operations. These net unit times were increased by a small percentage to cover miscellaneous operations not specifically identified in the time studies but a part of the job. Actual working times thus obtained were also increased to allow for scheduled rest periods and a minimum of unavoidable delay resulting from imperfect integration of the various operations. Where possible these "gross" unit time requirements were checked for reasonableness by comparison with unit times based on labor utilization and output data from the accounting records of a sample of firms. As developed, the production standards represent estimates of output rates that might be expected from average workers operating in plants efficiently organized in the sense that nonproductive time is held to a practical minimum.

SUMMARY

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ACKNOWLEDGMENTS

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Production standards for fixed-station jobs--such as "setup field box"--are given in Table A and do not vary with size of plant. Production standards for trucking operations are given in Table B. The output rates given decrease moderately as size of plant increases to allow for minor increases in trucking distances. Transport distances for different size plants were estimated from typical plant layouts, while time requirements in relation to transport distance were estimated from data published in earlier reports.[1/]

Floor Space Requirements

Floor area requirements are affected primarily by size of plant, type of in-plant transportation and packer supply equipment used, and the rate of output per packer. Estimated requirements developed from typical packing house layouts and studies of space allocations in actual plants are given in Table C. This table gives: (a) the total floor area required, including space for all packing house operations, office, supplies storage, and miscellaneous requirements; (b) the space required for the packer supply operations only, that is, receiving and temporary storage of incoming fruit and packing-line equipment; and (c) cull storage. The space allocations given for storage of incoming fruit and culls are based on a cull percentage of 30 per cent, but moderate variations from this percentage would not greatly alter the space requirements indicated.

Replacement Costs, Building

The unit costs of building space are affected primarily by locality, type and time of construction, and size of building. Replacement costs per unit floor area are given in Table D for buildings of different size and for two types of packing house construction, that is, buildings suitable for the use

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[1/] Sammet, L. L., In-Plant Transportation Costs as Related to Materials Handling Methods--Apple and Pear Packing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, January, 1953) p. 53. (Giannini Foundation Mimeographed Report No. 142.) Processed.

Transport distances were based on plant layouts appropriate for a 30 per cent cull operation. The effect of variations in cull proportions on trucking distances would be small, however, and was ignored in the analysis.

of hand trucks and fork-lift trucks. The costs are based on engineering estimates of 1950 replacement costs and are adjusted to the 1953 price level. Some information as to construction details and a reference to more complete data concerning these costs and the indices used to adjust for price variations over time are given in the footnotes to the table.

Replacement Costs, Equipment

Data for estimating the quantities and replacement costs of equipment required for the packer supply operations are given in Table E. With some items the estimating procedure is simple. One fork truck, for example, is provided for each fork-truck operator, and the replacement cost for a 4,000-pound capacity gas engine unit is given in the table as $4,200. The procedure with other items is slightly more involved. For example, in estimating the requirements and costs of a cull conveyor for use with the manual supply type of packing-line equipment, it is necessary to estimate the amount of in-line conveyor required, allowing 3 feet 8 inches of conveyor length for each packer station; it is also necessary to compute the length of cross conveyor required if the plant contains more than one packing line. Estimating the conveyor replacement costs involves computing the sum of three quantities: (a) a fixed amount of $265 per drive section (at least one drive section per packing line would be required with the maximum conveyor length per drive section limited to 100 feet; minimum belt width is 10 inches); (b) an amount equal to $8.10 times the total length of conveyor in feet; and (c) an amount equal to $1.05 multiplied by the conveyor length in feet times the quantity of culls transported over a given drive section in 1,000 pounds per hour. (Since the cross conveyor may be increased in width as additional culls are received from successive packing lines, the conveyor design and the computation of this final item may involve the provision of several drive sections in the cull cross conveyor, with the conveyor width increasing at successive packing lines as additional culls are picked up.) Data for estimating requirements and costs for items of this type are given in the table. The replacement costs are based on the 1953 price level and include allowances for a 3 per cent state sales tax and delivery and installation costs.1/

1/ The types of equipment used in packing fresh grapes are relatively simple. Installation costs are generally a small proportion of the total cost and, for the items included in Table E, average about 5 per cent of the installed cost.

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Annual Charge for Equipment and Buildings

In computing total season costs with different methods, it is necessary to provide for the eventual replacement of durable items such as the building or equipment having several years' use life. In this report this is done by including an annual fixed charge for such items, computed in terms of a percentage of the replacement costs. The percentage charge includes allowance for depreciation, insurance, taxes, interest, and fixed repair expense. The depreciation rates used are intended to reflect the expected use life for the various types of equipment; insurance rates are those quoted by insurance companies for risk conditions typical of fruit packing houses; taxes are included as a representative amount; interest is estimated at the approximate rate of 5 per cent on the undepreciated balance of the investment; and "fixed repair" expense is estimated as a percentage of replacement cost, the amount depending on the type of durable. The percentages used involve important elements of judgment and in some respects are arbitrary. However, they reflect practices that are fairly representative of current cost accounting procedures among fruit packers and shippers.

Estimates of Variable and Annual Fixed Costs

An example of the computation of the variable and annual fixed costs of the packer supply operation is given in Table G. The example is based on the use of manual supply type of packing-line equipment, hand trucks for in-plant transportation, a plant output rate of 600 lugs per hour, a packer output rate of 10 lugs per packer hour, and a culling rate of 30 per cent of the total fruit run.

Under "volume handled," Table G gives the number of incoming field boxes and cull boxes handled at different rates of output of packed standard lugs.

Under "Equipment Requirements and Replacement Costs," estimated quantities and costs for the various items of equipment required at different rates of output are given. Data for estimating each item are obtained from the preceding tables. For example, with a plant output rate of 600 packed lugs per hour, building space requirements for the packer supply operations are 8,000 square feet (see Table C which also gives total building space requirements for the rate of output and type of operation under consideration as 14,200 square feet); and unit building costs per square foot are about $2.14 (based on the total building area required--see Table D). Replacement costs of the space required for the packer supply operations then are $17,048. Similarly,

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the requirements and costs of the remaining equipment items (packing stations, cull boxes, and hand trucks) may be estimated from the data in Table E. Total replacement costs for the building and equipment required in the above example are given in Table G as \$20,920. Using the percentage annual charge given in Table F for the various types of equipment, the annual fixed charge for buildings and equipment in this example is \$2,263.

In a like manner, labor requirements and costs may be estimated using the production standards in Tables A and B. For example, in a hand-truck plant of 600-lugs-per-hour capacity, using the manual supply type of packing-line equipment, the production standard for receiving and transporting incoming fruit and reloading empty field boxes is 230 boxes per hour (Table B). To handle the 800 field boxes per hour involved in the above example would require 3.47 man-hours of labor per plant hour. This would require a receiver-trucker crew of 4 men. Similarly, disposal of culls at the rate of 206 boxes per hour requires cull-trucking labor at the rate of 0.65 man-hours per plant hour (indicating a 1-man crew) and cull-dumping labor at the rate of 0.62 man-hours per plant hour (indicating a 1-man crew). The crew for handling cull and field boxes then would total 6 men. These operations are related closely enough, however, to permit "pooling" the receiving and cull-handling operations so that surplus labor in one category can be used in another. On this basis, the total labor required would be 4.73 man-hours per plant hour. This indicates a total field-box and cull-handling crew of 5 men as shown in Table G. In addition to the above, labor is required to set up field boxes for the packers and to place and remove cull boxes. This involves handling 800 field boxes and 206 cull boxes, the production standard for both of which is given in Table A as 145 boxes per man-hour. Handling a total of 1,006 boxes at this rate would require 6.94 man-hours of labor per plant hour or a crew of 7 men. For the total crew of 12 men, labor costs at the rate of \$1.05 per hour are \$12.60 per hour.

An additional variable expense included in the example in Table G is for equipment repair. This is estimated at the rate of 0.5 per cent of the equipment replacement cost per 100 hours of operation. In this example it amounts to 19 cents per hour. Total variable costs then are \$12.79 per hour.

Costs in Relation to Output Rate

To place the many cost calculations for different types of equipment and different operating conditions in summary form, "average" relationships of

the type described on page 17 were developed graphically. The method used is illustrated in Figure A which shows the effect of rate of plant output on annual fixed charges, variable costs per hour, and total season costs. The costs shown apply to a hand-truck plant, using manual supply type of packing-line equipment, with a packer output rate of 10 lugs per packer hour and 30 per cent of the total fruit run trimmed out as culls. These are the operating conditions and methods on which Table G is based.

The cost points computed in Table G for the annual fixed charge and variable costs per hour are shown in Parts A and B of Figure A, and these data were supplemented to provide additional cost points at plant volume intervals of 100 lugs per hour. Total season costs computed from these data are shown in Part C of Figure A.

Study of the cost points in Figure A indicates that, while the increase in costs as plant output rate increases is slightly irregular, a good approximation of this relationship is given by the straight lines "smoothed" graphically through these points. Since these "average" relationships greatly simplify the cost comparisons between different methods and operating conditions, they were used as the basis for the results presented in this report and constitute the summary of cost relationships given in Tables H and I of this Appendix.[1]

Summary Cost Relationships

A summary of the cost relationships developed in the manner described above for the different methods and operating conditions considered in this report is given for hand-truck plants in Table H and for fork-truck plants in Table I. In each table data are given which relate costs to proportion of

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[1] Transformation of the equations for annual fixed charges and variable costs per hour shown in Parts A and B of Figure A will yield the following equations for total season cost: for a 250-hour season, total season cost = $0.900 + 0.763P$; for a 750-hour season, total season cost = $1.300 + 1.789P$ (in which "P" represents plant output rate in 100 lugs per hour and the costs given by the equations are expressed in thousands of dollars). Comparison of the transformed equations with those in Part C of Figure A--which are based on total season cost points computed from data in Table G for specific rates of plant output--indicates a close correspondence in the equations obtained by the two procedures. Similar results would occur with data for other operating conditions and methods. Since it was simpler to develop the cost relationships in terms of equations for annual fixed charges and variable costs, as in Parts A and B in Figure A, this procedure was followed.

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cull fruit, type of packer supply equipment and cull-handling methods used, rate of output per packer hour, and size of plant. The two cost categories, "annual fixed charges" and "variable cost per hour," are presented. The data for each cost category involves a constant, or fixed, cost element and an additional cost related to rate of packed output. For example, costs in a hand-truck plant (Table H) using manual supply type of packing-line equipment, having a packer output rate of 5 lugs per packer hour and a culling rate of 15 per cent, are given in the table as follows: annual fixed charge--$657, plus $377 per 100-packed-lugs-per-hour capacity; variable costs per hour--60 cents, plus $1.60 per 100-packed-lugs-per-hour capacity. If the capacity output rates of this plant were 600 packed lugs per hour, the annual fixed charge for equipment would amount to $2,919 and the variable cost per hour, $10.20.

APPENDIX TABLE A

Production and Time Standards for Fixed-Station Jobs Performed in the Packer Supply Operations for Packing Fresh Table Grapes, California

Job[a]	Type of trucking equipment used[b]	Miscellaneous, per cent of direct operating time[c]	Minimum delay, per cent of standard time[d]	Production and time standards	
				Minutes per box	Boxes per man-hour
Dump cull boxes: Transfer full cull box from stack on floor to dumping position; empty contents; restack empty lug on floor or pallet.	HT	5	20	.180	335
	FT	5	20	.188	320
Fill cull box at conveyor chute: Transfer empty box from stack on floor or pallet to cull-conveyor chute; wait for fill; transfer full lug to stack on floor or pallet.	HT	5	20	.395	150
	FT	5	20	.410	145
Set off field box--conveyor supply line: Transfer empty field box from box conveyor to stack on floor or pallet.	HT	--	20	.103	585
	FT	--	20	.108	555
Set up field box--conveyor supply line: Transfer full field box from stack on floor or pallet to packer supply conveyor:					
Including restack empty box from conveyor return.	HT	8.0	20	.301	200
	FT	15.0	20	.340	175
Set up full lug only.	HT	8.0	20	.150	400
	FT	15.0	20	.170	350
Set up field box--manual supply line: Transfer empty field box from rack at packer station to stack on floor or pallet; replace with full box; walk between packer stations.	HT	4.0	20	.414	145
	FT	10.0	20	.460	130
Set up cull box--manual supply line: Transfer full cull box from cull chute at packer station to stack on floor or pallet; replace with empty box; walk between packer stations.	HT	4.0	20	.414	145
	FT	10.0	20	.460	130

[a] All jobs involve handling field or cull boxes. Approximate dimensions of cull and field boxes: 18" x 24" x 7" high (including 1" cleat on each end). Approximate average net weights: field box, 30 pounds; cull box, 34 pounds.

[b] Code as to trucking equipment used: "HT" represents "hand truck"; "FT" represents "fork truck."

[c] Miscellaneous work not included in the operations described is performed on some jobs. Examples are periodic clean-up of spilled fruit, disposal of broken boxes, etc. The time spent in such operations is expressed as a percentage of the labor required to perform the operations specified in the column on left.

[d] Approximately 4 per cent of the total delay represents allowance for scheduled rest periods (usually ten minutes at the midpoint of a four-hour work period).

APPENDIX TABLE B

Production Standards for Trucking Jobs Performed in the Packer Supply Operations in Packing Fresh Table Grapes, California

Item	Type of packer supply operation	Plant output rate, lugs packed per hour	Production standard, boxes per man-hour[a]					
			Hand-truck plant			Fork-truck plant		
Packer output rate: (lugs per packer hour)			5	10	20	5	10	20
Receiving:								
Prepare receiving ticket; unload grower truck and transport boxes to temporary storage; transport to setup (or set-on) station; return empty boxes to temporary storage, then to grower's truck.	Manual	200		240			790	
		400		235			775	
		600		230			765	
		800		225			760	
		1,000		220			750	
	Conveyor	200		290			865	
		400		280			855	
		600		270			845	
		800		260			840	
		1,000		250			830	
Cull disposal:								
Transport culls from setup position to temporary storage; return empty boxes to setup.	Manual	200	350	375	390	970	985	985
		400	305	345	370	960	980	985
		600	265	315	350	950	975	980
		800	240	295	330	945	970	980
		1,000	215	275	310	940	965	975
Transport cull boxes from temporary storage to cull dumping station and return empty boxes to temporary storage.	Manual or conveyor	200 to 1,600		275			1,305	

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[a] Computed from standard unit time requirements and rounded to the nearest five boxes per hour. Allowances for miscellaneous work (not specified in the job description but incidental to the job) and minimum unavoidable delays are as follows. Unload and reload grower's truck: delay--20 per cent of gross work time; miscellaneous--10 per cent of net work time. All other trucking operations: delay--20 per cent of gross time; miscellaneous--5 per cent of net time.

Load sizes in boxes hauled per trip: Hand trucks--full field boxes, 10; empty field boxes, 12; cull boxes, 8. Fork trucks--full field boxes, 60; empty field boxes, 78; cull boxes, 60.

Trucking time requirements per trip were estimated from time and distance relationships previously reported. See Sammet, L. L., In-Plant Transportation Costs as Related to Materials Handling Methods--Apple and Pear Packing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, January, 1953), p. 53. (Giannini Foundation Mimeographed Report No. 142.) Processed.

Trucking distances estimated from typical plant layouts.

APPENDIX TABLE C

Floor Space Requirements in Packing California Fresh Table Grapes as Affected by Type of In-Plant Transportation Equipment Used and Plant and Packer Output Rates (Cull Fruit, 30 Per Cent of Total Run)[a]

Field-box supply method and item	Packer output rate, lugs per packer hour	Floor area, 1,000 square feet									
		Hand-truck plant					Fork-truck plant				
Plant output: (lugs per plant hour)		200	400	600	800	1,000	200	400	600	800	1,000
Manual:[b]											
Total floor area	5	8.3	13.2	18.0	22.9	27.8	7.8	12.7	17.5	22.4	27.2
	10	7.1	10.6	14.2	17.7	21.2	6.0	9.1	12.1	15.2	18.2
	20	6.6	9.5	12.4	15.3	18.2	5.2	7.3	9.5	11.6	13.8
Temporary storage for incoming fruit and culls; packing lines	5	4.9	8.3	11.7	15.0	18.4	5.6	9.5	13.5	17.4	21.3
	10	3.7	5.8	8.0	10.1	12.2	3.6	5.5	7.5	9.4	11.3
	20	3.1	4.6	6.1	7.6	9.2	2.9	4.1	5.4	6.6	7.8
Conveyor:[b]											
Total floor area	5	7.8	11.9	15.9	20.0	24.0	5.9	8.9	12.0	15.0	18.0
	10	7.1	10.2	13.2	16.3	19.4	5.0	7.2	9.4	11.6	13.8
	20	6.8	9.4	12.0	14.6	17.2	4.4	6.2	7.9	9.7	11.5
Temporary storage for incoming fruit and culls; packing lines	5	4.4	7.0	9.6	12.2	14.8	3.5	5.6	7.8	9.9	12.0
	10	3.6	5.4	7.1	8.8	10.6	2.6	3.8	5.1	6.3	7.5
	20	3.2	4.5	5.8	7.1	8.4	2.2	3.0	3.7	4.5	5.3
Manual or conveyor:											
Cull storage[c]	5 to 20	0.2	0.4	0.5	0.6	0.7	0.2	0.2	0.3	0.3	0.4

[a] Based on analysis of floor space allocation observed in actual plants, dimensional data for standard equipment, and study of typical plant layouts. Floor areas required for the temporary storage of incoming fruit and culls are based on a culling rate of 30 per cent of the total fruit run. Variations in these space requirements as per cent of culls vary were included in the analysis. However, the effects are minor and are omitted from this table.

[b] See page   for description of field-box supply methods.

[c] Cull storage area not affected by variations in field-box supply methods or in packer output rates. When cull bin is used in lieu of temporary storage in boxes, the bin is located outside the plant and no in-plant storage space is required.

APPENDIX TABLE D

Estimated Replacement Costs Per Unit Floor Area in Relation to Size of Plant and Type of In-Plant Transportation Equipment Used for Field and Cull Boxes
Packing Fresh Table Grapes, California, 1953

Total roofed area, 1,000 square feet	Average cost per square foot[a]	
	Hand-truck plants[b]	Fork-truck plants[c]
	1,000 dollars	
4	3.56	3.59
8	2.60	3.02
12	2.29	2.84
16	2.13	2.74
20	2.03	2.69
24	1.97	2.65
28	1.92	2.62
32	1.89	2.60
36	1.86	2.59
40	1.84	2.57
44	1.82	2.56
48	1.81	2.55

[a] Based on detailed engineering estimates of packing house construction costs made in 1951 and adjusted to 1953 price level. See Sammet, L. L., and I. F. Davis, Building and Equipment Costs, Apple and Pear Packing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, December, 1952), 38p. (Giannini Foundation Mimeographed Report No. 141.) Processed.

[b] Building consists of wood-frame structure with a wood floor at truck-bed height. Exterior walls are surfaced with a single layer of wood sheathing, except office spaces which have an interior finish. Clear height from floor to underside of roof trusses is 12 feet. Roof span--30 to 40 feet. All areas roofed except empty lug storage.

[c] Building consists of a concrete slab at ground level, wood side walls and wood-frame roof construction. Roof truss span--75 to 100 feet. Clear height from floor to underside of roof trusses--18 feet. All areas roofed except storage of empty field boxes.

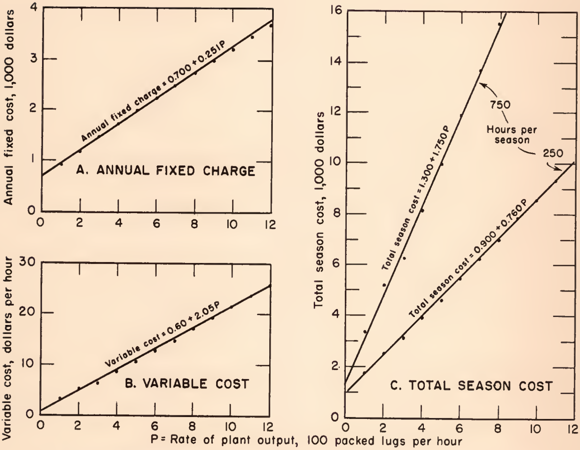

Fig. A. Annual fixed charges, variable costs per hour, and total season costs of the packer-supply operations in relation to rate of packed output. The costs apply to fresh grape packing operations in a hand truck plant using manual-supply packing-line equipment and nonmechanized cull and empty field box handling methods, with 30 per cent cull fruit and a packer output rate of 10 lugs per packer hour.

APPENDIX TABLE E

Requirements and Estimated Replacement Costs of Equipment Used in Packer Supply Operations in Packing Fresh Table Grapes, California, 1953

Item and quantity required	Replacement cost[a]
CULL EQUIPMENT	
Cull bin:	
Minimum bin volume, 100 cubic feet; to this, add 110 cubic feet of bin volume per 1,000 pounds culls run per hour.[b]	$3.00 per cubic foot bin volume
Cull boxes:	
For rates of cull accumulation less than 200 boxes per hour, provide 300 boxes plus 6.0 times the number of cull boxes run per hour. For rates of culling greater than 200 boxes per hour, provide 1,130 boxes plus 2.5 times the number of cull boxes run per hour.[c]	90 cents per box
Cull conveyor:[d]	
Manual field-box supply: One belt conveyor per packing line (length equal to 3 feet 8 inches times number of packing stations) plus cross conveyor of length equal to 30 feet times number of packing lines. Conveyor field-box supply: Cross conveyor of length equal to 22 feet times number of packing lines. (In-line conveyor for culls is furnished with field-box supply equipment.) (Note: With either system, width of belt is 3¼ inches times culls run expressed in terms of 1,000 pounds run per hour. Minimum width, 10 inches.)	The sum of the following three items: (a) $265 per drive section[e] (b) $8.10 times conveyor length in feet (c) $1.05 multiplied by conveyor length in feet times culls transported, expressed in 1,000 pounds per hour
Cull elevator:	
Length, two times vertical distance to top of bin. Compute width as described above for cull conveyor (minimum width, 10 inches).	The sum of the following three items: (a) $265 (b) plus $8.90 times conveyor length in feet (c) $1.35 multiplied by conveyor length in feet times culls transported, expressed in 1,000 pounds per hour

(Continued on next page.)

Appendix Table E continued.

Item and quantity required	Replacement cost
FIELD BOX CONVEYOR	
Manual field-box supply:	
One per packing line, extending full length of line, plus cross conveyor in multiline plant (length of cross conveyor equal to 30 feet times number of packing lines).	The sum of the following items: (a) \$280 per drive section[e/] (b) \$9.30 times conveyor length in feet
Conveyor field-box supply:	
Cross conveyor in multiline plant of length equal to 22 feet times number of packing lines. (In-line conveyor for empty field boxes is furnished with field-box supply equipment.)	
PACKING STATIONS	
One per packer. Maximum number of stations per line with conveyor method of packer supply, 40. (Reduce number of stations per line if rate of feed for field boxes exceeds 600 per hour per conveyor line.)[f/]	
Manual field-box supply:	
Includes packing station, cull chute, and racks for field and cull boxes.	\$33 per station
Conveyor field-box supply:	
Includes packing station, cull chute, rack for field boxes, automatic chain conveyor for field-box supply, empty-box conveyor, and cull belt. (Empty-box and cull conveyors extend only to end of packing line.)	\$2,700 per line plus \$240 per packing station
PALLETS	
One pallet per 60 cull boxes	\$4 each
TRUCKS (Hand Truck or Fork Lift)	
One truck per operator:	
Hand truck (side dump)	\$84 each
Fork truck (4,000 pound capacity, gas engine)	\$4,200 each

(Continued on next page.)

Appendix Table E continued.

a/ 1953 price level. Includes costs of freight, sales tax (3 per cent), and installation.

b/ Provides storage capacity for 8-hour run. Based on cull weight of 40 pounds per cubic foot.

c/ Provides storage capacity for 16-hour run when culling rate is 34 boxes per hour and storage for 4-hour run when culling rate is 500 boxes per hour. (Average net weight per box, 34 pounds.)

d/ In cull belt design and cost estimation, width of belt may be adjusted in each drive section in proportion to cull load carried.

e/ Maximum recommended length per drive section is 100 feet. Fixed element of cost covers the drive mechanism and applies to each drive section.

f/ Two types of conveyor equipment for the field-box supply are in common use. Since cost relationships were found to be about the same with either type of equipment, data concerning only one type are given so as to simplify the table. Equipment specified above consists of a central conveyor system in each packing line from which field-box distribution and cull collection is provided for packing stations on each side of the conveyor system. A second type of equipment is similar in operation, except that the conveyor systems supply packing stations on only one side of the conveyors. This reduces the maximum number of packing stations per line to 20. Estimated replacement costs for this type of equipment are given by the sum of the following items: (a) $1,170 per packing line and (b) $260 per packing station.

APPENDIX TABLE F

Percentage Annual Charge for Buildings and Equipment Used in Packing Fresh Table Grapes, California, 1953

Item	Estimated use life	Depreciation	Interest, taxes, insurance[a]	Fixed repair	Total
	years	per cent of replacement cost			
Transportation:					
Conveyor (box)	15	6.7	5.0	1.5	13.2
Conveyor (fruit culls)	10[b]	10.0	5.0	3.0	18.0
Pallets	10	10.0	5.0	1.5	16.5
Trucks: fork lift	10	10.0	5.0	1.5	16.5
Trucks: hand	15	6.7	5.0	1.5	13.2
Packing-line equipment:	15	6.7	3.0	1.5	13.2
Structures:					
Concrete (slab and walls)	40	2.5	3.0	1.8	8.9
Concrete slab and wood walls	33	3.0	3.0	1.8	9.6
Wood frame and deck	33	3.0	3.0	2.0	10.0

[a] Insurance--1.0 per cent; taxes--1.0 per cent; and interest--3.0 per cent of replacement cost (the interest charge amounts to approximately 5 per cent of the undepreciated balance).

[b] Average use life, based on 15-year use life for the mechanical part of the conveyor and a 5-year use life for belting.

TABLE G

The Effect of Rate of Output of Packed Fruit on the Costs of the Packer-Supply Operations in Packing Fresh Table Grapes. (Culls, 30 Per Cent of Total Fruit Run; Manual Packer-Supply Operations; Hand-Truck Plant; Packer Output Rate, Ten Lugs Per Packer Hour.) California 1953

Item	Output rates, labor and equipment quantities and costs									
VOLUME HANDLED[a]										
Packed output rate: Lugs per hour at 28 pounds net	200		400		600		800		1,000	
Incoming fruit: Field boxes per hour at 30 pounds net	267		533		800		1,067		1,333	
Culls: Cull boxes per hour at 34 pounds net	69		137		206		274		343	
EQUIPMENT REQUIREMENTS AND REPLACEMENT COSTS	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Building: Receiving, packing and cull-storage space; quantity, 1,000 square feet floor area[b]	3.7		5.8		8.0		10.1		12.2	
Unit replacement cost[c]										
Total cost, dollars		9,860		13,508		17,048		20,544		24,010
Packing stations: Number required	20		40		60		80		100	
Total cost at $33 each, dollars		660		1,320		1,980		2,640		3,300
Cull boxes: Number required	715		1,120		1,635		1,800		1,970	
Total cost at 90 cents each, dollars		643		1,010		1,472		1,621		1,773
Hand-clamptruck: Number required	2		3		5		7		8	
Total cost at $84 each, dollars		168		252		420		588		672
Total equipment and building replacement cost, dollars		11,331		16,090		20,920		25,393		29,755
Total annual fixed charge, dollars[e]		1,201		1,725		2,263		2,747		3,218
VARIABLE REQUIREMENTS AND COSTS										
Labor--number of workers: Receiver-trucker Truck and empty cull boxes	2		3		5		7		8	
Setup	3		5		7		10		12	
Total labor cost at $1.05 per hour, dollars		5.25		8.40		12.60		17.85		21.00
Variable repair expense: At 5 per cent of equipment replacement cost per 100 hours' use		.07		.13		.19		.24		.29
Total variable cost, dollars per hour		5.32		8.53		12.79		18.09		21.29

[a] Output rate measured in terms of standard display lugs. Number of incoming field boxes and cull boxes estimated from output rate, the net weights indicated and culls at 30 per cent of total fruit run.

[b] Space requirements given are for packer output rate of ten boxes per packer hour.

[c] Unit building costs are based on total floor space requirements. Costs per square foot in relation to lugs packed per hour are: 200 lugs--$2.67; 400 lugs--$2.32; 600 lugs--$2.14; 800 lugs--$2.03; 1,000 lugs--$1.96. See Tables C and D.

[d] Labor requirements for receiver-trucker and cull trucker and dumper are based on the assumption that the labor force for these jobs can be pooled.

[e] Annual fixed charge for equipment estimated on the basis of the following percentages of replacement cost: cull boxes, 16.5; building, 10.0; and all other equipment, 13.2 per cent. See Table F for details.

TABLE H

The Effect of Work Method and Type of Equipment Used, Rates of Packer and Plant Output, and Proportion of Cull Fruit on Costs of Packer-Supply Operations in Packing Fresh Table Grapes Hand-Truck Plants, California, 1953[a]

Method	Packer output, lugs per packer hour[b]	Costs in relation to proportion of cull fruit and packer and plant output rates[b]											
		15 per cent culls[c]				30 per cent culls[c]				45 per cent culls[c]			
		Annual fixed charge		Variable cost per hour		Annual fixed charge		Variable cost per hour		Annual fixed charge		Variable cost per hour	
		Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity
		dollars											
MANUAL PACKER SUPPLY													
Method A: No mechanization of cull handling	5	657	377	.60	1.60	700	402	.80	2.11	768	441	1.09	2.86
	10	638	228	.62	1.58	700	251	.80	2.05	799	286	1.12	2.84
	20	616	152	.62	1.56	700	173	.80	2.01	834	206	1.13	2.82
	30	616	125	.62	1.56	700	160	.80	2.01	834	170	1.13	2.82
Method B: Cull conveyor,with cull boxing	5	550	613	.46	1.78	600	669	.60	2.31	675	753	.84	3.18
	10	534	358	.46	1.73	600	402	.60	2.26	698	468	.84	3.13
	20	513	235	.46	1.72	600	275	.60	2.25	731	336	.83	3.10
	30	513	190	.46	1.72	600	220	.60	2.25	731	290	.83	3.10
Method C: Cull conveyor, plus overhead cull bin	5	539	659	.46	1.45	600	733	.60	1.75	687	839	.72	2.17
	10	520	406	.46	1.40	600	468	.60	1.70	713	556	.72	2.12
	20	498	284	.46	1.39	600	341	.60	1.67	743	423	.71	2.10
	30	498	230	.46	1.38	600	290	.60	1.67	743	360	.71	2.08
Method D: Cull conveyor and bin, plus empty field-box conveyor	5	685	769	.93	1.72	750	843	1.20	2.04	844	948	1.44	2.52
	10	662	459	.93	1.64	750	520	1.20	1.96	875	607	1.44	2.44
	20	634	307	.93	1.61	750	363	1.20	1.92	913	442	1.43	2.40
	30	634	250	.93	1.61	750	310	1.20	1.92	913	380	1.43	2.40
CONVEYOR PACKER SUPPLY													
Method B: Cull conveyor, with cull boxing	5	717	1,059	.50	1.74	750	1,108	.60	2.15	804	1,188	.81	2.95
	10	703	577	.47	1.60	750	615	.60	2.00	826	677	.84	2.76
	20	684	359	.46	1.51	750	394	.60	1.93	923	484	.86	2.70
	30	684	280	.46	1.50	750	320	.60	1.93	923	400	.86	2.69
Method C: Cull conveyor, plus overhead cull bin	5	802	1,097	.37	1.52	850	1,162	.40	1.73	920	1,258	.48	2.15
	10	782	615	.34	1.36	850	669	.40	1.58	949	747	.51	1.95
	20	759	398	.34	1.28	850	447	.40	1.51	983	516	.52	1.89
	30	759	320	.34	1.27	850	330	.40	1.50	983	420	.52	1.89
Method D: Cull conveyor and bin, plus empty field-box conveyor	5	898	1,123	.35	1.69	950	1,188	.40	1.89	1,026	1,283	.48	2.14
	10	876	628	.32	1.31	950	681	.40	1.60	1,057	758	.49	1.87
	20	852	409	.35	1.28	950	456	.40	1.46	1,093	524	.53	1.85
	30	852	325	.35	1.28	950	340	.40	1.46	1,093	450	.53	1.85

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[a] Cost relationships derived from graphical solutions similar to those presented in Figure A, 1953 price level.

[b] Detailed analysis made only for packer output rates of 5, 10, and 20 boxes per hour. Relationships with packer output rate of 30 lugs per hour obtained by graphic extension of the coefficients of the cost equations.

[c] Per cent of culls in relation to total fruit run.

TABLE I

The Effect of Work Method and Type of Equipment Used, Rates of Packer and Plant Output, and Proportion of Cull Fruit on Costs of Packer-Supply Operations in Packing Fresh Table Grapes Fork-Truck Plant, California, 1953[a]

Method	Packer output, lugs per packer hour[b]	Costs in relation to proportion of cull fruit and packer and plant output rates[c]											
		15 per cent culls[b]				30 per cent culls[b]				45 per cent culls[b]			
		Annual fixed charge		Variable cost per hour		Annual fixed charge		Variable cost per hour		Annual fixed charge		Variable cost per hour	
		Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity	Constant cost	Add per 100 lugs per hour capacity
		dollars											
MANUAL PACKER SUPPLY													
Method A: No mechanization of cull handling	5	1,200	683	.80	1.36	1,200	744	.80	1.96	1,200	828	.80	2.68
	10	1,100	408	.80	1.35	1,100	469	.80	1.94	1,100	552	.80	2.67
	20	1,100	299	.80	1.34	1,100	361	.80	1.94	1,100	440	.80	2.66
	30	1,100	260	.80	1.34	1,100	280	.80	1.94	1,100	400	.80	2.66
Method B: Cull conveyor, with cull boxing	5	1,050	925	1.60	1.36	1,050	995	1.60	1.91	1,050	1,144	1.60	2.91
	10	950	544	1.60	1.29	950	604	1.60	1.84	950	738	1.60	2.84
	20	850	402	1.60	1.26	850	464	1.60	1.83	850	586	1.60	2.22
	30	850	350	1.60	1.25	850	420	1.60	1.82	850	540	1.60	2.21
Method C: Cull conveyor, plus overhead cull bin	5	1,050	960	1.80	1.25	1,050	1,053	1.80	1.57	1,050	1,190	1.80	1.91
	10	1,050	566	1.80	1.19	1,050	649	1.80	1.50	1,050	771	1.80	1.85
	20	1,000	414	1.80	1.16	1,000	501	1.80	1.48	1,000	621	1.80	1.82
	30	1,000	360	1.80	1.15	1,000	450	1.80	1.47	1,000	580	1.80	1.82
Method D: Cull conveyor and bin, plus empty field-box conveyor	5	1,250	1,064	2.80	1.45	1,250	1,156	2.80	2.08	1,250	1,294	2.80	2.23
	10	1,150	624	2.80	1.36	1,150	707	2.60	1.95	1,150	830	2.80	2.14
	20	1,050	449	2.80	1.31	1,050	536	2.60	1.89	1,050	656	2.80	2.10
	30	1,050	380	2.80	1.30	1,050	480	2.60	1.87	1,050	610	2.80	2.08
CONVEYOR PACKER SUPPLY													
Method B: Cull conveyor, with cull boxing	5	1,000	1,341	1.10	1.51	1,000	1,383	1.10	1.88	1,000	1,505	1.10	2.50
	10	1,120	768	1.10	1.34	1,120	809	1.10	1.70	1,120	912	1.10	2.33
	20	1,120	514	1.10	1.27	1,120	555	1.10	1.64	1,120	650	1.10	2.26
	30	1,120	420	1.10	1.25	1,120	465	1.10	1.61	1,120	550	1.10	2.23
Method C: Cull conveyor, plus overhead cull bin	5	1,020	1,343	1.10	1.32	1,020	1,427	1.10	1.53	1,020	1,550	1.10	1.82
	10	1,000	806	1.10	1.15	1,000	870	1.10	1.36	1,000	969	1.10	1.65
	20	970	542	1.10	1.08	970	619	1.10	1.29	970	725	1.10	1.58
	30	970	435	1.10	1.05	970	515	1.10	1.26	970	640	1.10	1.56
Method D: Cull conveyor and bin, plus empty field-box conveyor	5	1,000	1,384	1.40	1.40	1,000	1,468	1.40	1.52	1,000	1,591	1.40	1.70
	10	990	832	1.40	1.07	990	897	1.40	1.24	1,000	995	1.40	1.54
	20	1,000	561	1.40	.98	1,000	638	1.40	1.17	1,000	743	1.40	1.45
	30	1,000	450	1.40	.97	1,000	540	1.40	1.14	1,000	660	1.40	1.43

a/ Cost relationships derived from graphical solutions similar to those presented in Figure A, 1953 price level.

b/ Detailed analysis made only for packer output rates of 5, 10, and 20 boxes per hour. Relationships with packer output rate of 30 lugs per hour obtained by graphic extension of the coefficients of the cost equations.

c/ Per cent of culls in relation to total fruit run.